RAYLEIGH WAVE DISPERSION STUDIES
OF
CRUSTAL AND UPPER MANTLE STRUCTURE
IN
NEW GUINEA

by

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for the degree of

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Except as stated herein, this thesis contains no material which has been accepted for the award of any other degree or diploma in any university, and to the best of my belief, the thesis contains no copy or paraphrase of material previously published or written by another person, except where due reference is made in the text herein.

J. A. Brooks.

(J. A. Brooks)

December, 1969

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ABSTRACT

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Variations in depth to 300 km below the tectonically stable platform of southern New Guinea were determined from recordings of fundamental and higher mode Rayleigh waves. This average profile for paths shorter than 2000 km, contains a low velocity zone reaching 4.2 km/sec. at depths of 120 to 160 km, which is overlain by a relatively thick cap of material with a velocity of 4.4 km/sec.

The lateral gross distribution of shear velocities beneath the crust, emerged from examination of fundamental mode dispersion profiles. Many of the phase velocity profiles were resolved from single station data and techniques used to define the correct dispersion in such cases are discussed. Although interpretations of these are strictly limited in structurally heterogeneous regions such as New Guinea, phase velocities at periods near 40 seconds are controlled mainly by shear velocities in the uppermost 50 km of the mantle, in zones of greater homogeneity than the crust.

Known geophysical data, existing hypotheses of geotectonic development of the New Guinea region, the concept of sea floor spreading, and observed characteristics of mineral assemblages under high temperatures and pressures, provide a framework within which these data are examined.

Upper mantle velocities are highest, about 4.7 km/sec., beneath the crust of the Solomon Sea, lowest beneath the shield structure of

southern New Guinea and appear to have intermediate values beneath the cordilleran region. These differences are large enough to indicate that regional variations exist in the mineralogy of the upper mantle.

The relatively low velocities underlying the southern New Guinea crust may also imply a higher heat flow than normally expected in the most ancient pre Cambrian shield regions of the world.

In general the results are not sufficiently detailed or comprehensive to test existing hypotheses of geotectonic development of this complex region and the study should rather be treated as a basic contribution to knowledge of the New Guinea area.

Page ix, line 6: for "pre Cambrian" read "Precambrian".

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1. INTRODUCTION

1.1 SCOPE OF THE STUDY

This thesis presents interpretations of recordings of dispersed Rayleigh wave trains for several paths in the New Guinea area. Results include "crustal" thicknesses and upper mantle shear velocities found by numerical inversion of phase velocities relating to the six regions marked in Fig. 1, and are presented against the background of previous geological and geophysical studies of the region.

1.2 CONTRIBUTIONS OF THE THESIS

I believe the work offers contributions in two respects. Firstly, it provides new data for a part of the south west Pacific area not specifically examined geophysically, in a regional sense, until the present decade. Secondly, and from a seismological point of view, four aspects can be mentioned:

(i) It is useful to be able to describe the earth in terms of regional transfer functions for various kinds of transmission, irrespective of the interpretations made in terms of physical models. In this study, phase velocity dispersion profiles are derived for several small regions, some of them structurally heterogeneous on a pronounced scale. While velocities remain the most widely studied parameter of travelling surface waves, dispersion profiles comprise the most useful part of the transfer function. No information about path attenuation is deduced here.

(ii) Usually, the depth to which structural information is obtained, becomes less as the length of the waveguide

decreases. Therefore, data which provide good penetration over short paths are extremely useful. The higher modes of surface wave transmission offer such a facility (Kovach and Anderson, 1964), and this study presents a shear velocity profile to a depth of 300 km for path lengths of between 1000 and 2000 km. Similar profiles for regions elsewhere e.g. Brune & Dorman (1963) involved much longer paths. The profile for southern New Guinea discussed here, depended on the analysis of higher mode Rayleigh waves which, simultaneously with the fundamental mode, controlled the numerical interpretation.

(iii) A feature of the analysis is the reliance placed on "single station" phase velocities, requiring an examination of the source phase term and its frequency dependence. The approach adopted was strictly empirical. Group velocities were used to determine the magnitude of the source phase term, and the small degree of its variation with frequency was demonstrated by close agreement of several events.

(iv) The evaluation of crustal thickness employed a variation of the numerical inversion technique by using Poisson's Ratio as a criterion to establish a preferred solution.

1.3 TERMINOLOGY

Definitions given by the American Geological Institute (1962) have been followed in this thesis.

1.4 BACKGROUND TO THE STUDY

In 1958 I was appointed to direct the Port Moresby Geophysical Observatory during its establishment and early years of operation. One of the main tasks of the Observatory involved routine seismological recording, and it soon became obvious that the future activities of the establishment would have a strong seismological bias because of the intense seismicity of the New Guinea-Solomon Islands region.

At that time, no regional geophysical studies of this tectonically complex region were known to me, and facilities were inadequate to provide a basis on which regional structure could be examined seismologically. An early attempt is represented by Appendix V of this thesis (Brooks, 1962). I presented these findings to the Tenth Pacific Science Congress, Honolulu, preceding a brief visit to California in 1961. During my visit to the Seismological Observatory at Pasadena, my interest was aroused by Professor Frank Press in the possible use of surface waves as an economic, effective tool for studying gross crustal and upper mantle structural variations, in circumstances such as then existed in New Guinea. Such a program for the European Alpine region (Knopoff & Press, 1961) had recently commenced. On my return to Port Moresby a similar proposal was devised and its aims outlined by Brooks and Ripper (1966).

The equipment was delivered in 1964, field recording began in 1965, and culminated in the preparation of this thesis.

It was apparent, quite soon after the first records were made, that hand methods of analysis would not suffice, although no computing facilities were then available in New Guinea.

However, in 1965 I was granted a two year post-graduate Scholarship to the University of Tasmania, Department of Geology, by the Commonwealth Public Service Board with the support of the Director, Bureau of Mineral Resources, to develop methods of analysis and interpret the data then

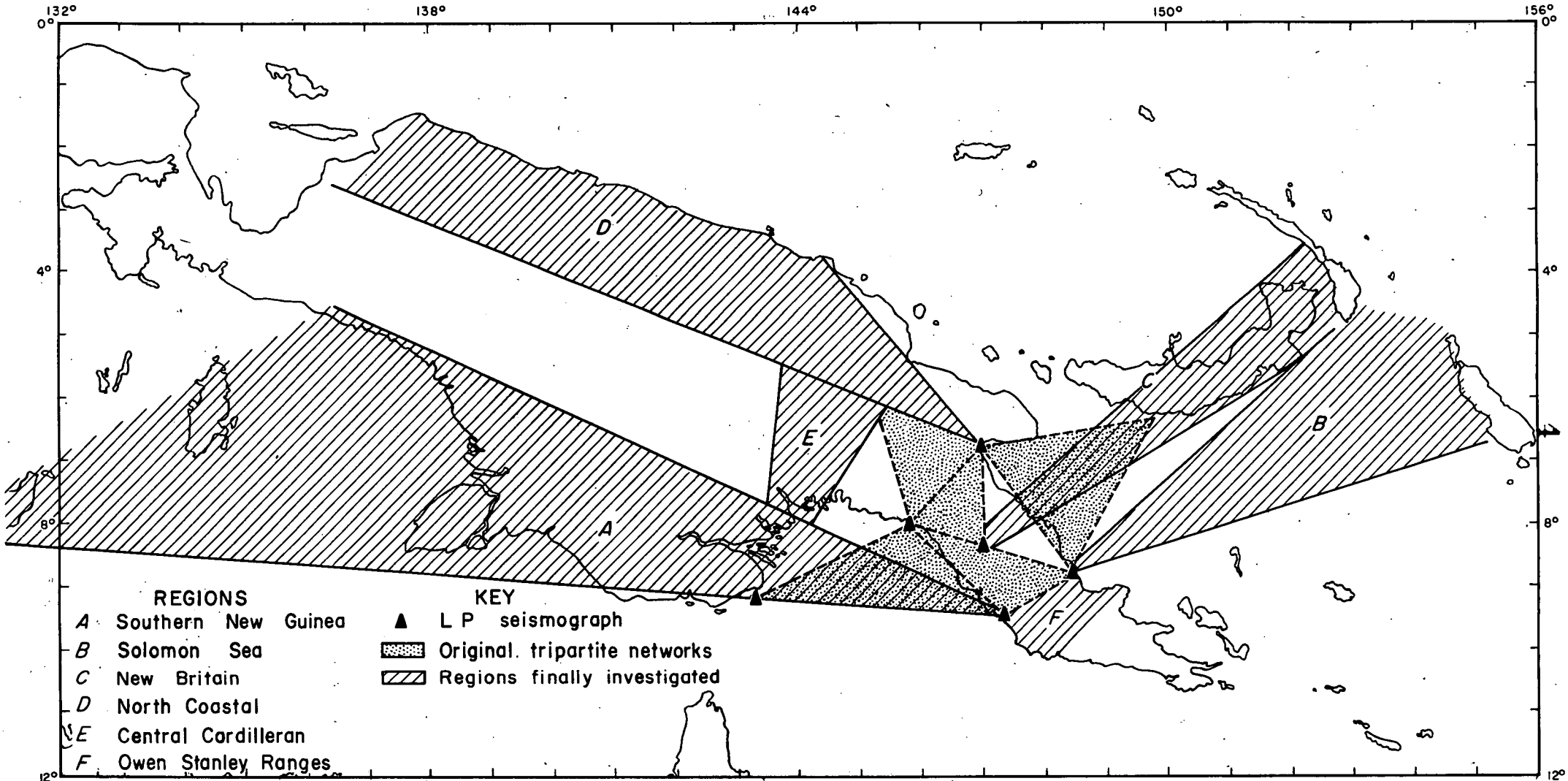

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FIG. 1 MAP OF REGIONS STUDIED

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becoming available. The venue was chosen at the invitation of Professor S. Warren Carey because the proposal combined well with his stimulating Papua-New Guinea Tectonic Project. This comprehensive multiple investigation was designed by Professor Carey to collate, supplement and interpret existing unpublished geological and geophysical data held on exploration company and government files, especially the Bureau of Mineral Resources. The geological phase of the project is represented by the unpublished theses of Smith (1964), Pitt (1966) and Kugler (1968).

The surface wave project was incorporated in the geophysical phase of the study represented in addition, by gravity studies of Shirley (1964) and St. John (1967).

1.5 THE PROJECT

1.5.1 Conception

The original field program was designed to measure phase velocities across triangular networks of single component long period vertical seismometers, after the manner of Press (1956) and Knopoff & Press (1961).

A schedule was devised to allow four to six months occupation of each network, followed by relocation of one or more seismometers to cover a new area. Station locations were chosen so that, as far as possible, the regions covered by each network did not include parts of two radically different topographic, and hence structural, units, e.g. shield, cordilleran, oceanic. Communication and especially transport difficulties in the Territory also constrained the choice of station locations, shown in Fig. 1. Fig. 2, of the Tapini outpost illustrates the difficult topography of some station environments. It is accessible only by light aircraft.

FIG. 2 TAPINI.

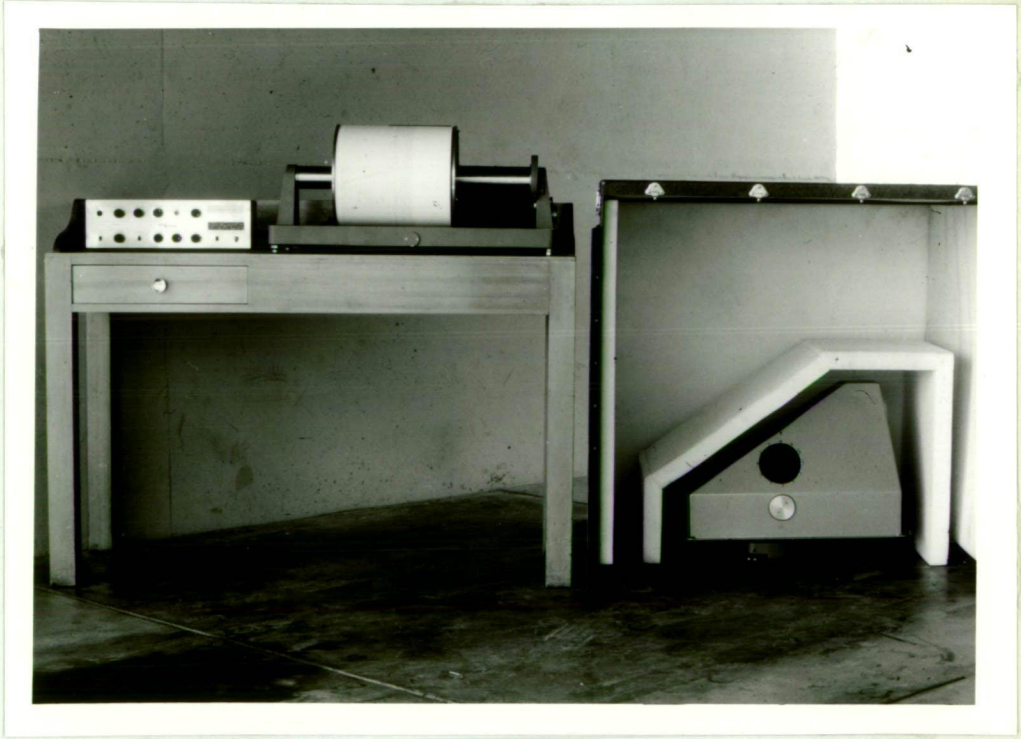

FIG. 3 SEISMOMETER INSULATION

FIG. 4 GRASS THATCHED SEISMOMETER "VAULT" POPONDETTA.

FIG. 5 CONCRETE BRICK, GRASS ROOFED SEISMOMETER "VAULT" TAPINI.

1.5.2 Equipment

The problems of operating, remotely and indirectly, long period seismographs in tropical conditions, governed the choice of equipment, and outweighed the desirability of including three component instruments. The equipment chosen was:

Seismometer: SV-282 Press-Ewing type (UED) T_o = 15 sec.
Critical damping was employed.

Recorder : ER-230 Pen recorder (UED) employing a passive filter. System response is discussed in Appendix VI but is similar to that of the World Wide Standard equipment. A recorder drum speed of 60 mm per minute was chosen for good time resolution.

Timing : Crystal oscillator controlled timing and power units, model NCD2, were especially designed and built in the B.M.R. laboratories for the project (Jones, 1968). They provided 40 w. of regulated power to drive the recorder.

This unit employed a pulse count comparator and display unit, calibrated in milliseconds to facilitate measurement of time errors by non-technical operators, and maintained chronometer rates of a few tens of milliseconds per day.

1.5.3 Seismometer housing

Considerable thought was given to this because of the extreme temperature sensitivity of long period seismometers employing the "zero-length" spring. Planned technical inspections of equipment at 3 week intervals required the seismometer to operate without the need to readjust the pendulum during this interval. Fig. 3 shows the double unit insulation system which in turn was housed in temporary structures of the type shown in Figs. 4 and 5. These structures employed local building materials, were very economical to construct, and had good thermal insulation propoerties.

1.5.4 Field Operations

Daily routine duties were undertaken by Papuan or New Guinean attendants employed locally. Special consideration was given to the design of a log sheet to show details of the record change, time comparison and step function calibration, in the most direct manner, with a minimum possibility of errors.

Technical servicing of field stations was carried out by personnel from the Port Moresby Observatory.

1.5.5 Analytical Approach

The planned interpretation of tripartite recordings failed for two main reasons:

(i) Wavetrains from sources outside the New Guinea region were disturbed before reaching the recording area, by interference from laterally reflected and refracted wavetrains with the parent wavetrain. Pilant and Knopoff (1964) and Knopoff et al, (1967), discussed some aspects of this problem. The phase errors were large enough to dominate the phase shift over such a small network as Port Moresby-Tapini-Popondetta. Extreme selectivity of seismograms was needed to obtain data of even moderate quality. Apart from the structural variations of tectonic units surrounding the region, in all azimuths, the irregularly shaped coastline of the island of New Guinea itself introduced added complexity to the problem.

(ii) Logistic problems encountered in the maintenance of field stations prevented the required continuity of recording by three stations simultaneously, and the large quantity of data needed in the circumstances was not acquired.

These difficulties were being recognised when it became clear that similar problems had arisen with a similar type of structural analysis of the European Alpine region (Pilant, Mueller & Knopoff, 1966) which had commenced in 1960 (Knopoff & Press, 1961).

Late in 1966 I decided, because suitable data was lacking, to change the emphasis of the project to an analysis of records of earthquakes occurring within rather than outside the New Guinea region.

The disadvantage of this approach was that single station records were employed, requiring investigation of the source phase term, and consideration of travel time errors due to limited accuracy of path lengths. Furthermore, structural information was averaged over regions much larger than covered by each original tripartite array.

TABLE 1

Operational Periods of Field Stations

STATION	ABBREVIATION	PERIOD OF OPERATION-
Port Moresby (W.W.S.S.S.)	PMG	May 1965 - May 1967
Popondetta	POP	May 1965 - November 1965
Tapini	TPN	May 1965 - February 1967
Kerema	KER	February 1966 - March 1967
Daru	DRU	February 1966 - October 1966
Lae	LAE	December 1966 - May 1967

By contrast however, a much wider range of structures could be examined and the new technique also offered more originality

(i) in employing near earthquakes, i.e. $\Delta < 1{,}000$ km, for the first time.

(ii) in the method used to estimate the source phase.

Fig. 1 compares the regions finally investigated with the original proposals.

The periods for which various stations were occupied are disclosed in Table 1 without detail indicating periods of satisfactory or unserviceable operation.

1.6 DATA

A total number of 127 seismograms involving 80 sources was digitised at intervals of $\frac{1}{2}$, 1 or 2 seconds, depending on the record character.

53 of these source - station paths were used in some way during interpretation of structure beneath the regions shown in Fig. 1.

A catalogue of source, mode and path information for these data is given in subsequent chapters where each region is discussed.

1.7 OTHER INVESTIGATIONS

Before 1960, information about the tectonics of the New Guinea region was represented, almost solely by the work of Stanley (1923), Carey (1938 a,b), van Bemmelen (1939), David (1950) and Glaessner (1950).

Even now, few publications have dealt quantitatively with the gross crustal structure of New Guinea. Most of what is known, or currently accepted, has emerged as a by product of extensive geological and geophysical oil search activities undertaken both in the western and eastern sections of the island, and is mainly confined to the upper five kilometres or so of the crust, e.g. Visser and Hermes (1962), APC (1961).

Recent studies fall into three categories:

(a) Those comprising the Papua-New Guinea Tectonic Project, organised by Professor S.W. Carey and consisting of the

tectonic analyses by Smith (1964), Pitt (1966), Kugler (1968), the gravity study of Shirley (1964) and the comprehensive analysis of the regional gravity field and tectonic synthesis by St. John (1967).

(b) A series of geological reports by the Bureau of Mineral Resources covering several regions within eastern New Guinea, and summarised by Thompson and Fisher (1965).

(c) Isolated seismological studies e.g. Brooks (1962) - P & S velocities; Doyle & Webb (1963) - Pn residuals; Brooks (1965, a,b) - seismicity; Brooks & Ripper (1966) - group velocities; Denham (1968) - crustal thicknesses.

An early analysis of special interest by Visser & Hermes (1962) included a hypothetical profile of the lower crustal boundary from the southern to the northern coast of West Irian. Crustal thicknesses ranging from 10 to 20 km off the north coast to about 40 km under the Van Rees Mountains and central range areas, thinning to 30 km or more under the plains of southern New Guinea were associated with a Bouger anomaly profile ranging between ±100 mg. Visser & Hermes disclosed extensive thicknesses of sediments extending to the top of crystalline basement at depths of five or more km.

The gravity implications of similar basins in eastern New Guinea comprising the southern marginal elements of the Papuan Geosynclinal System (Smith, 1964) is discussed by St. John (1967) whose analysis was based on a standard crust of 35 km beneath the zero Bouger anomaly contour in southern Papua, and a crust-mantle density contract of 0.5 gm/cc. These basins are sufficiently extensive to affect Rayleigh wave dispersion (Brooks & Ripper 1966). According to St. John, crustal thickness variations exceeding 25 km occur between the central cordillera and the Solomon Sea.

Rose, Woollard and Malahoff (1968) have made a preliminary interpretation of the gravity field in the Solomon Sea and Solomon Islands

employing a crust-mantle density contrast of 0.46 gr/cc and a standard 32 km crustal section. Departures from zero Bouger anomalies were then interpreted as a function of water depth, free air anomaly and crustal thickness. Estimates of thickness ranged from 5 km under the trench west of Bougainville, to 10 km under the central Solomon Sea basin and 20 km under Bougainville Island.

Reinforcing the overall picture of regional instability apparent from the high seismicity, these studies of the gravity field provided strong evidence of variations in grosg crustal structure within New Guinea.

Seismology has contributed little to an understanding of this structural problem. Some inferences as to the probable broad characteristics of the crust both north and south of New Guinea have been drawn. Kuo et al (1962), in discussing broad categories of crustal structure in the Pacific Basin, inferred from Rayleigh wave group velocities, commented that the Melanesian-New Zealand area west of the Andesite line showed distinctively different characteristics from the Pacific Basin proper. Specifically they noted that the path between the Banda Sea and Fiji represented neither a typically oceanic nor continental structure.

A comprehensive study of group velocity dispersion observed over a number of intersecting paths in and around the Pacific led Santo (1963) to infer that the crust immediately to the north and south of New Guinea was chiefly continental in broad characteristics. Brooks & Ripper (1966) noted an apparent progressive thickening of the crust for a sequence of paths radiating from Port Moresby, southwest to the West Australian coast, west to Timor and finally northwest across the New Guinea Cordillera. This conclusion was subsequently supported by the gravity data (St. John, 1967).

Earlier, Doyle & Webb (1963) had studied Pn residuals at Rabaul and Port Moresby from Pacific nuclear explosions, and concluded that a 'continental type' crust underlay Port Moresby and an 'island type' crust underlay Rabaul. Subsequently Denham (1968) suggested values of about

31 km and 14 km respectively for these locations, from spectral studies of P waves.

2. SURFACE WAVE ANALYSIS

2.1 GENERAL REMARKS

The purpose of this chapter is to examine the analytical approach employed in this investigation and review the important sources of error or misinterpretation associated with dispersion studies, particularly those relying on the "single station" technique.

The theoretical and observational basis for the extensive surface wave investigations of the last decade is well established in the literature. A decade ago, analytical reductions were still largely dependent on hand analysis methods to measure dispersion and were confined to well dispersed wavetrains. Interpretations were comparatively crude and confined to simply structured waveguides with one variable parameter (usually thickness). The effects of lateral heterogeneity, anisotropy and source characteristics have only recently received attention.

Phase velocity measurements have supplanted the earlier reliance on group velocity, and may be determined in several ways employing one or more stations. Investigations of structures beneath the Canadian Shield by Brune and Dorman (1963) and the European Alps by Knopoff et al (1966), provide good illustration of the use of two and three stations respectively. Networks with more stations have been used by Aki (1961) and Alexander (1963). The use of multiple stations allows measurements over small areas, with dimensions of the order of a wavelength, provided the waveguide is sufficiently homogeneous that phase errors, of the kind disclosed by Knopoff, Berry and Schwab, (1967), are avoided.

Apart from the work by Brune et al (1960) and Kuo et al (1962), single station methods have not really been trusted because of source characteristic uncertainties.

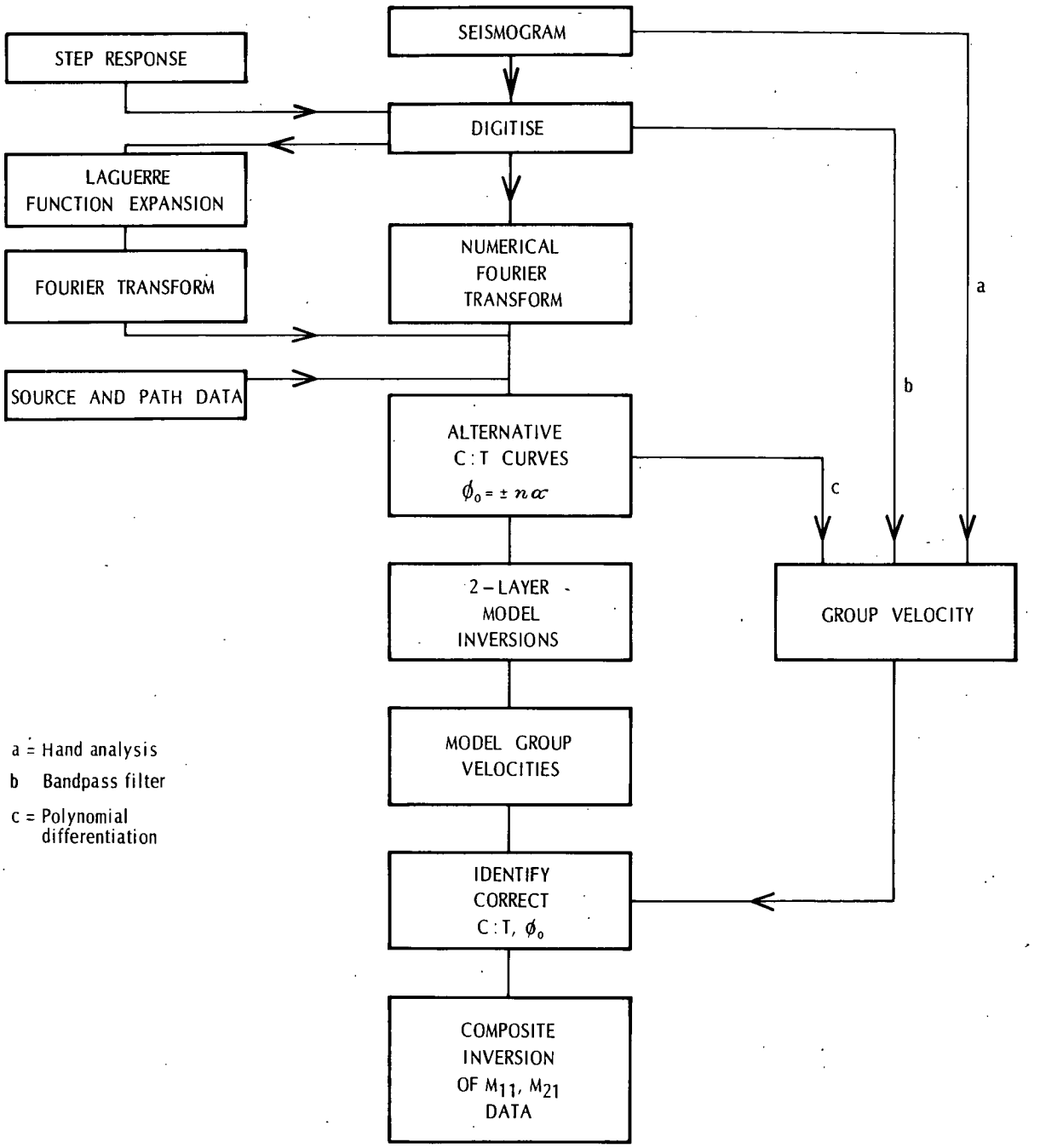

FIG. 6. ANALYSIS FLOW CHART

2.2 ANALYSIS

2.2.1 Data Processing Scheme

A diagrammatic illustration of the analytical approach is shown in Fig. 6. This was not wholly automatic, as results required subjective assessment at intermediate stages.

2.2.2 Phase Velocity Calculations

Phase velocities were computed from the Fourier spectrum, $F(\omega)$, of each digitised Rayleigh wave train, $f(t)$.

Thus, for a plane wave front, the phase angle, $\theta(\omega)$ (relative to some defined origin) of a particular frequency, ω (radians/sec.) can be shown to be (Appendix Ia),

$$\theta(\omega) = \omega t - kr + \phi(\omega) + \phi_o(\omega) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where t = interval from origin time to beginning of wave train

k = wave number $= \omega / C(\omega)$, C = phase velocity

$\phi(\omega)$ = phase delay introduced by the seismograph system

$\phi_o(\omega)$ = apparent initial phase at the source

r = epicentral distance (kms)

Solutions for the displacement potential of a disturbance originating from a point or line source, i.e. spherical or cylindrical waveforms, require an additional nett phase correction of $\pi/4$, sometimes called the "spreading correction" (see Appendix Ib). Thus from (1), the phase velocity is given by

$$C(\omega) = \omega r \Big/ \left\{ \omega t - \theta(\omega) + \phi(\omega) + \phi_o(\omega) + \pi/4 \right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$\phi_o(\omega)$ was first determined by a Fourier-Laguerre transformation (Dean, 1964) of the seismograph step function response which was recorded daily. (Appendix VI).

The $F(\omega)$ from which θ were derived, were then computed using a

numerical integration routine (Appendix Ia), and listed out with the transform. Usually θ traversed several cycles for the period range 15 to 60 seconds.

$\theta(\omega)$ was computed at standard frequency intervals of 0.002 cycles/sec., sufficiently small so that the phase difference between adjacent points was always less than a full circle.

Calculation of a family of phase velocity profiles commenced at the long period end of the spectrum at a frequency, ω, selected beforehand by inspection of the record. In the case of the fundamental mode, ω usually ranged between .014 and .03 cycles/sec. A trial $C(\omega)$ was first computed from $\theta(\omega)$. The angle ϕ_o was then varied by increments of π until a value of $C(\omega)$ between, or nearest, the interval 3.80 to 4.10 km/sec. was found. A family of dispersion curves was computed for each event by arbitrarily assigning to $\phi_o(\omega)$, incremental values corresponding to $\pm n\alpha$; $n = 0, 1, 2$; $\alpha = \pi/2$ so that phase velocities remained within a physically plausible range e.g. 3.5 to 4.5 km/sec. for the fundamental mode in the period range 40 to 70 seconds. Brune et al (1960) shows several examples of such families of curves. The choice of α is discussed below.

Program output (Appendix VII) took the form of an optional listing of the Laguerre coefficients and step function frequency transform followed by the Rayleigh wave transform and the table of alternative phase velocity, profiles together with initial phase. The frequency range covered by the transform and the velocity profiles were controlled by variables set following a visual examination of each record to estimate the part of the spectrum containing useful amplitudes.

2.2.3 Profile Selection

(a) Choice of Initial Phase Increment (α)

The objective here is to establish a basis for choosing an angle α, such that the correct ϕ_o is within $\pm \alpha/2$, and hence by assigning $\phi_o = \pm n\alpha$

to compute dispersion curves, and corresponding models, bridging or closely approximating, the correct curve. There have been few "single station" analyses which have relied on postulated values of ϕ_o. One such example is that of Kuo et al (1962) who considered values of $\pm n\pi/2$ for Rayleigh waves in the period range 20-140 sec. The paths used were several thousand km long and consequently their possible alternative dispersion curves were separated, even at the long period end, by only very small velocity increments, making a confident assignment of ϕ_o a difficult exercise.

The source parameter ϕ_o has been examined both theoretically and empirically by several workers.

Brune et al (1960) established $\phi_o = \pm n\pi$ $(n=0,1,2\ldots)$ in model studies in which a spark discharge provided the source, and applied this result to study Rayleigh waves from nuclear explosions. Its application to earthquake records would seem justified if the source were shown to be of basically impolsive or explosive type, and there have been suggestions to this effect, e.g. Evison (1967).

Others have tested the more widely held hypothesis of a fault (shear failure) source having a basic single or double couple action.

Aki (1960) et seq, used cross correlation techniques to estimate ϕ_o to within about $\pi/8$. His definition of ϕ_o does not include the spreading correction, thus $\phi_o = \phi_o(\text{Aki}) - \pi/4$. Aki (1962) summarised the derivation of ϕ_o from Lamb's 1904 studies of horizontal and vertical displacements due to impulsive sources, and extended the findings to the strike and dip slip cases and found $\phi_o = 0, \pi$ (strike slip) and $\phi_o = \pm\pi/2$ (dip slip).

Haskell (1963) theoretically derived the radiation patterns expected from fault-type sources disposed in a variety of attitudes, adopting the convention for ϕ_o employed by Brune et al (1960). Apart from one example (Haskell (1963, p.635)), ϕ_o appears very close to $\pm n\pi/2$ for the extensive range of cases studied. Departures from this value are discussed in Appendix I(b).

Most empirical investigations of ϕ_o for Rayleigh waves and its

apparent azimuthal variation have involved only long period ($T > 100$ sec.) fundamental mode waves. The work of Brune et al (1961), Brune (1962) and Chander and Brune (1965) showed $\phi_0 = \pm n\pi/2$ for most azimuths, departures being confined to "cross-over regions" bridging the azimuthal fields of constant ϕ_0.

Thus almost all investigations have disclosed ϕ_0 to have values which are integral multiples of $\pi/2$ for all azimuths except the narrow azimuth ranges surrounding the "cross-over regions". Therefore $\alpha = \pi/2$ has been adopted, and found a satisfactory increment for ϕ_0 in this study. For the range of epicentral distances employed, adjacent dispersion curves are usually sufficiently separated so that (a) corresponding models are distinctive, and (b) an unambiguous indication of the correct ϕ_0 is given by superimposing sets of dispersion curves corresponding to different distances.

In this study the source - station paths are all similarly directed and epicentres are not widely separated. If the earthquake mechanism is tectonically controlled, one might expect similar values of ϕ_0 measured in the same quadrant.

(b) Identification of Dispersion Profile

The need arises now to identify the correct dispersion from the several alternatives available.

This is achieved either by comparison with two-station data, as in Chapter 3, Fig. 13, or by the scatter of points in the superimposed plot of sets of alternative profiles for several events.

Consider two events, and corresponding path lengths r_1 and r_2, beneath which the waveguide is identical. Initial phase angles at the source, ϕ_0 in section 2.2.3, are ϕ_{01} and ϕ_{02}.

Let ϕ_{11} and ϕ_{12} respectively be the values of initial phase, $n\pi/2$, adopted in each case. For particular choices of n, different for each event, ϕ_{11} and ϕ_{12} can be so chosen that

$$\Delta_1\phi_1 = \phi_{11} - \phi_{01} = n_1\pi/2 - \phi_{01} \leq \pm\pi/4 \qquad \ldots\ldots\ldots (3)$$

$$\Delta_1\phi_2 = \phi_{12} - \phi_{02} = n_2\pi/2 - \phi_{02} \leq \pm\pi/4 \qquad \ldots\ldots\ldots (4)$$

define the true discrepancy in adopted source phase. Travel time errors for waves of period T are

$$\Delta_1 t_1 = \frac{T \Delta_1 \phi_1}{2\pi} \qquad \text{and} \qquad \Delta_1 t_2 = \frac{T \Delta_1 \phi_2}{2\pi}$$

and resulting errors in phase velocity are

$$\Delta_1 c_1 = -\frac{T \Delta_1 \phi_1 r_1}{2\pi t_1^2} \qquad \text{and} \qquad \Delta_1 c_2 = -\frac{T \Delta_1 \phi_2 r_2}{2\pi t_2^2}$$

Assuming that $\frac{1}{t^2} \approx \frac{1}{t_1^2} \approx \frac{1}{t_2^2}$, where $t = (t_1 + t_2)/2$

$$\Delta_1 c_1 - \Delta_1 c_2 \approx \frac{T}{2\pi t^2} \left(r_2 \Delta_1 \phi_2 - r_1 \Delta_1 \phi_1 \right) \qquad \ldots\ldots\ldots (5)$$

Alternative values of phase velocity are defined by incremental changes of n_1 and n_2. Thus from (3), (4)

$$\Delta_2 \phi_1 = (n_1 \pm 1)\frac{\pi}{2} - \phi_{01} \qquad \text{and} \qquad \Delta_2 \phi_2 = (n_2 \pm 1)\frac{\pi}{2} - \phi_{02}$$

and, from (5)

$$\Delta_2 c_1 - \Delta_2 c_2 = \Delta_1 c_1 - \Delta_1 c_2 \pm \frac{T}{2\pi t^2} \cdot \frac{\pi}{2} \left(r_2 - r_1 \right)$$

Hence for each incremental change of ϕ_{11} , ϕ_{12} , the corresponding members of each set of profiles become further separated by incremental amounts $\frac{T}{4\pi t^2}(r_2 - r_1)$.

The standard deviation from a mean curve placed through each pair of profiles correspondingly increases, and this applies also to sets of more than two profiles.

Other errors considered below, (2.3.1), also exist, but are not dependent on ϕ_o and thus do not significantly influence changes in standard deviation resulting from changes in ϕ_o. Fig. 14, Chapter 3, illustrates the changing separation in the case of 2 events and Table 4 and Fig. 15 the increasing standard deviation within sets of profiles progressively removed from the correct dispersion curve.

Hence, a set of profiles having a "mean" profile, closer to the true average dispersion than any other set, will also show a smaller standard deviation from its mean than any other set. Alternatively two sets may

"straddle" the true dispersion curve in which case, the standard deviations will be nearly equal, and smaller than sets above and below them.

In practice, careful inspection is sometimes required to correctly group members in corresponding sets. Most difficulty arises where the path distance and origin time errors, section 2.3.1, are sufficiently large to distort the relative separation between profiles for events having nearly equal path lengths, for example, as in Chapter 4. To this extent, the profile matching procedure is subjective. Provided these supplementary errors vary in sign and magnitude for each earthquake, increased protection against their distorting influence, is afforded as the set of events used increases in size.

Correct matching is impossible if these supplementary path and distance errors are so large that discrete groups of profiles become "smeared" together. In practice this did not occur for any set of paths studied.

2.2.4 Group Velocity

If $k = \omega/C(\omega)$ is the wave number, then group velocity is given, from equation (1), section 2.2.2, by

$$U(\omega) = r/\{ t - \theta'(\omega) + \phi'(\omega) + \phi_o'(\omega) \} \qquad \ldots\ldots\ldots (5)$$

Thus $\bar{t} = t - \theta'(\omega)$ is defined as the group travel time.

Hence, whereas phase velocity depends on the source phase angle group velocity depends only on variation of ϕ_o with frequency. This is usually very small, and can safely be ignored.

The three methods used to calculate $U(\omega)$ are explained in Appendix III. They are:

(1) The simple and conventional hand analysis method, which is satisfactory provided the dispersion is not too rapid.

(2) The digital filter technique devised by Alexander (1963). This method was used for finding group velocities of the

higher modes at periods less than 30 sec.

(3) Direct differentiation of a polynomial fitted to sets in a Chebyschev sense. This proved useful provided the phase velocity profile was known over a large period range including long periods.

Fig. 6 schematically illustrates how group velocities were used to select the correct phase velocity profile (and hence initial phase) from the families of such curves (section 2.1.2 above).

Group velocity profiles were computed from models found by inverting various phase velocity profiles, and then compared with group velocities derived or measured directly.

2.2.5 Inversion

Methods of inverting phase velocity data to provide layer parameters of a hypothetical model having equivalent dispersion properties to those observed was first demonstrated by Dorman and Ewing (1962), and has since been applied by others. Brune and Dorman (1963) inverted both Love and Rayleigh fundamental modes to establish their CANSD model for the Canadian Shield. McEvilly (1964) tried a similar approach for the central U.S.A. and could not find a model compatible with both modes. Berry and Knopoff (1967) using fundamental Rayleigh mode data of only limited precision, found a model for the western Mediterranean.

Brune and Dorman (1963) list some important restrictions associated with the approach which, while not permitting a unique reduction does offer a less arbitrary interpretation of a phase velocity dispersion profile than previously available. These restrictions are to some extent a consequence of the part dependence of compressional and shear velocity and density on each other.

Model parameters are adjusted so that differences between observed and model dispersion is minimised in a least squares sense, as described by

Dorman and Ewing (1962) and the other authors mentioned above.

The partial derivatives $\partial C/\partial p_i$, $i=1,\ldots n$ of the n active or 'floating' parameters in a particular model, comprise the matrix of coefficients of the set of equations of condition for each of the m values of observed phase velocity. These are to be solved for corrections

$$\text{i.e.} \quad \sum_{i=1}^{n} \frac{\partial C}{\partial p_i} . dp_i = \alpha C_j \quad , \quad j = 1, \ldots m$$

where the αC_j are the differences between observed and model phase velocity.

Freedom to adjust the model is restricted in the following ways:

(i) Two or more parameters, p, should not be varied simultaneously if profiles of phase velocity sensitivity, $\partial C/\partial p$ as a function of period have similar or reversed outlines.

(ii) A parameter should not be allowed to vary in a particular problem if the maximum sensitivity $\partial C/\partial p$ is much less than the known precision of the data, ΔC. There is no point in adjusting p closer than $\Delta C / (\partial C/\partial p)$.

(iii) Successive iterations of a particular problem must produce a convergent solution. If this requirement is not met, successive iterations produce models which match the observed dispersion equally well while containing physically unrealistic layer velocities, densities or thicknesses.

Conditions (i), (ii), and (iii) express different aspects of a common problem of numerical instability associated with the use of the inversion technique.

Under conditions (i), above, the matrix of coefficients can approach singularity causing instability in the resulting solutions. For example the requirement prohibits the simultaneous adjustment of shear velocities and densities of the same model. If two such parameters are varied, especially where the sensitivity of phase velocity to one is much greater than the other, large and unreasonable adjustments are often made to the insensitive parameter

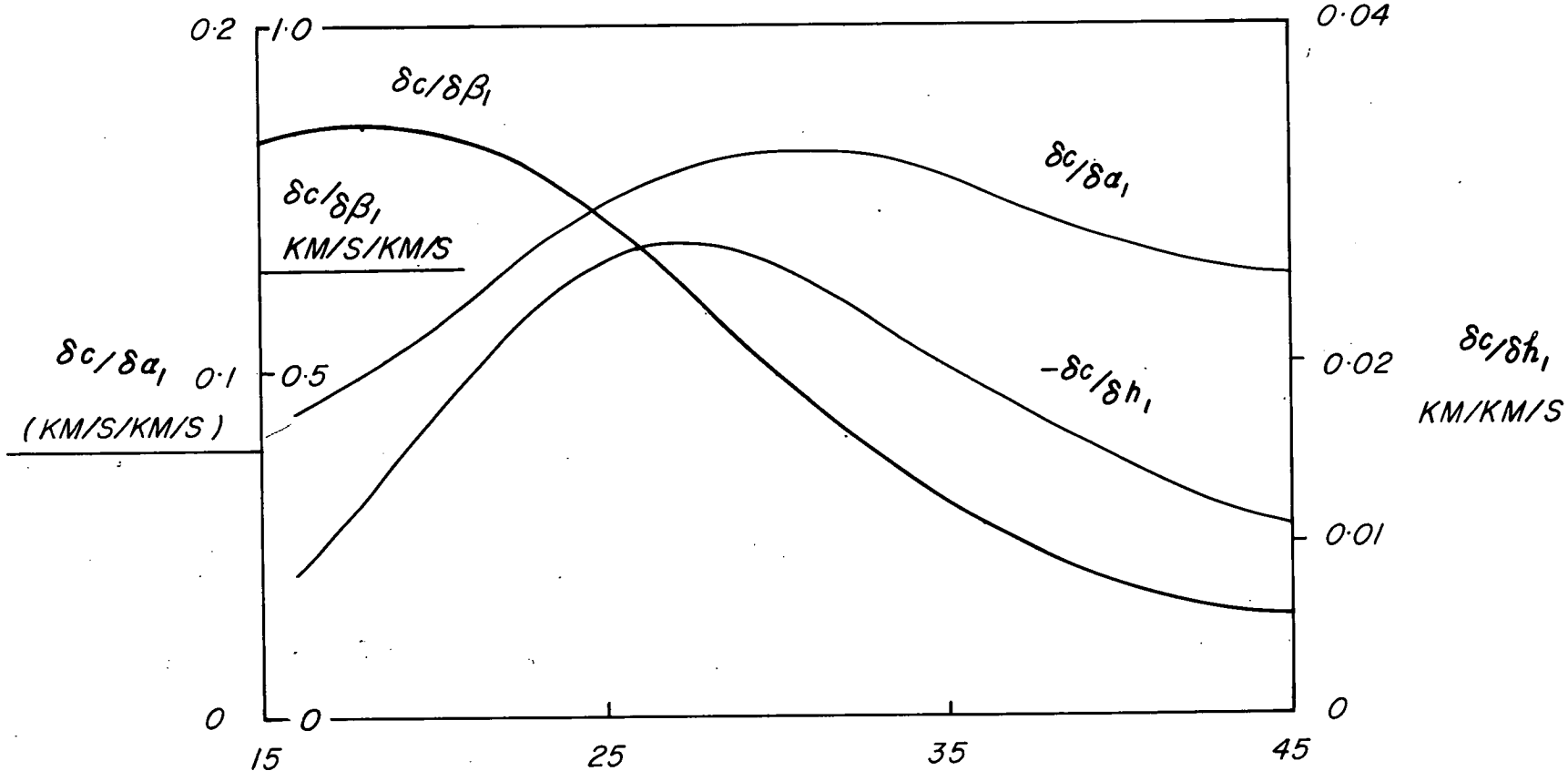

FIG. 7 A PARTIAL DERIVATIVES OF PHASE VELOCITY WITH RESPECT TO h_1, a_1, β_1, FOR MODEL Th I (DORMAN & EWING, 1962).

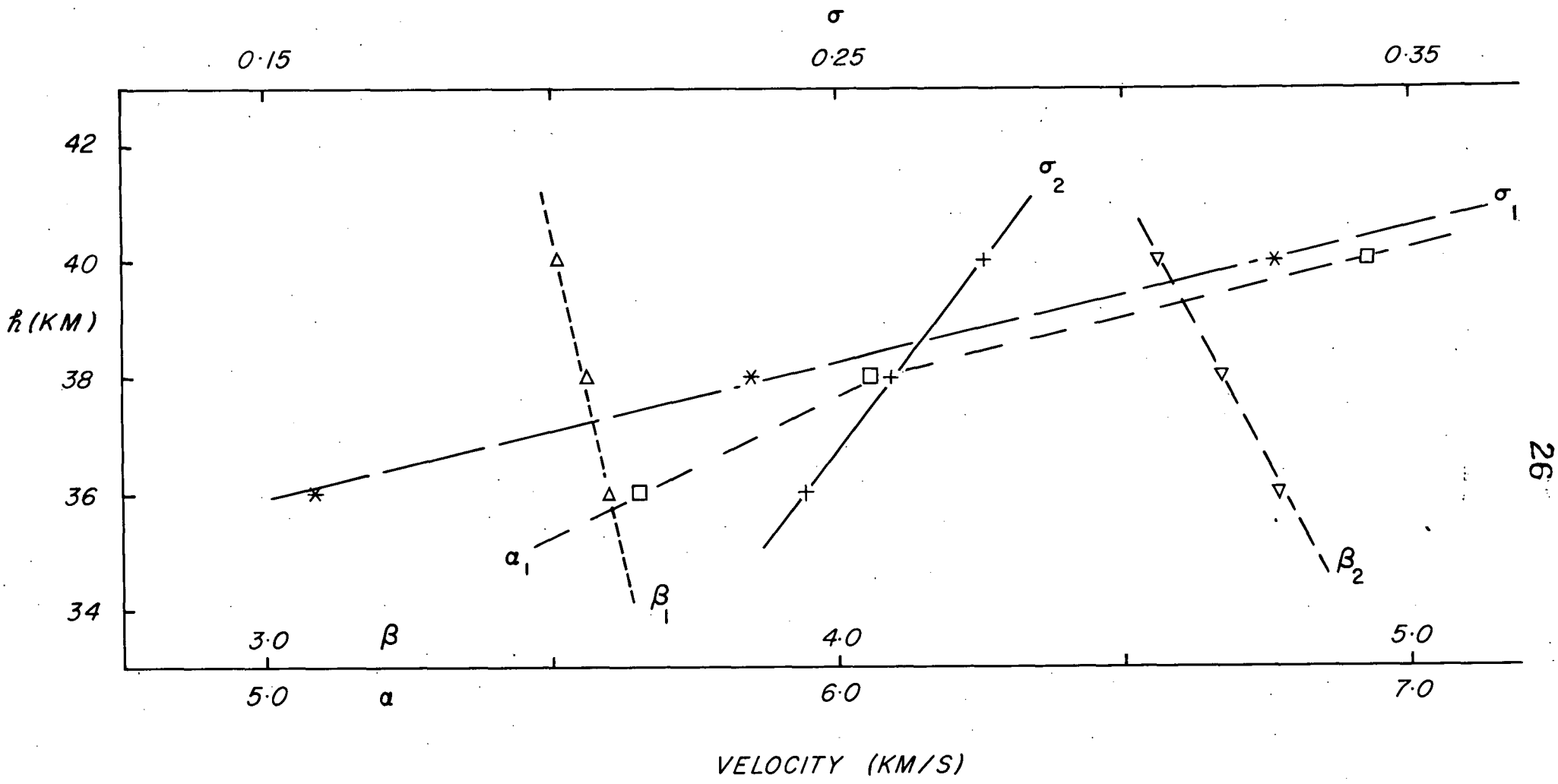

FIG 7B INVERSIONS OF PERTURBED MODEL Th I FOR CRUSTAL THICKNESS (h_1) VALUES 36, 38, 40 KM, REVEALING CHANGES IN σ , OF ABOUT ·04 PER KM CHANGE IN h_1.

which does not stabilise after a few iterations and develops a tendency to "hunt" in response to small changes in the more sensitive parameter. Such a pair are thickness and compressional velocity of the upper layer for 2 layer crust-mantle model. This particular model is widely used in this study to establish average depths to the M-discontinuity and the problem of realising a stable inversion was overcome in the following way:

Moho depths were determined by repeated inversion of data covering a restricted period range, in terms of a 2 layer model i.e. crust over semi-infinite mantle. In each inversion a different fixed value of crustal thickness (h_1) was used while crustal velocities α_1, β_1 and mantle shear velocity, β_2, were allowed to vary.

The unknown error in h_1, is absorbed mostly by α_1 because the shapes of the respective sensitivity: period profiles are similar, and partly by β_1 because α_1 and β_1 are not quite independent.

Using the relation

$\sigma_1 = (\alpha_1^2 - 2\beta_1^2)/2(\alpha_1^2 - \beta_1^2)$ to find Poisson's Ratio σ_1, it is easy to verify the statement of Kanamori and Mizutani (1965) expressing sensitivity of σ_1 to small changes $\Delta\alpha_1$ and $\Delta\beta_1$

i.e. $$\Delta\sigma_1/\sigma_1 \approx 3\{|\Delta\alpha_1/\alpha_1| + |\Delta\beta_1/\beta_1|\}$$

i.e. an error, Δh_1, causes an apparent variation, $\Delta\sigma_1$, thus

$$\Delta\sigma_1 \approx 3\sigma_1\{|(\partial C/\alpha_1\partial h_1)/(\partial C/\partial\alpha_1)| + |(\partial C/\beta_1\partial h_1)/(\partial C/\partial\beta_1)|\}\Delta h_1$$

The partial derivatives $\partial C/\partial h_1, \partial C/\partial\alpha_1, \partial C/\partial\beta_1$ to use in this formula can be obtained from a "representative" model. Those for Dorman & Ewing's (1962) model Th1 are shown in Fig. 7a. Representative values of .03, .15, .5, respectively indicate that a change of about .04 can be expected in σ_1 for each 1 km change in crustal thickness as shown in Fig. 7b. This figure would vary slightly for different models, but provides a convenient criterion to establish h_1, consistent with 'reasonable' values of σ_1 - see 2.2.9.

Condition (iii) above, characteristically occurs when layers are too thin, as sensitivity profiles $\partial C/\partial\rho$ for successive layers are similar. The

determination of optimum layer thicknesses is not easy but can be assisted partly by considering the shape of the displacement profile for a given mode and model as an adjunct to the sensitivity profiles. The amplitude profile (either vertical or horizontal component of displacement) should change appreciably over the depth range of a particular layer whose parameters are to be adjusted. Some protracted, but essentially simple tests were performed with synthetic data (Appendix IV). In these tests, phase velocities were computed for a 5 layer upper mantle model having layer thicknesses of 50 km or more. These velocities were then treated as observed data in four sets of inversions. The velocities were accepted at 5 place accuracy and also rounded to 2 decimal places. For each case, the model shear velocities were perturbed by setting them to a common value of 4.5 km/sec. Initial reductions were found for models in which layer thicknesses were unaltered. Additional tests, using models for which layer thicknesses were halved, were then made. Results given in the appendix clearly illustrate an instability for models with the split layers which was very slowly overcome only when the "observational" data was given to 5 places of decimals. Instability did not appear in the initial set of reductions, even with "observational" data given to 2 places of decimals.

2.2.6 The Inversion Programme

The program employed was developed from the version called INV3 written for an IBM 7090 computer (Fortran IV) by Brune and Dorman for their Canadian Shield investigation. This employed the Haskell matrix subroutine for calculating dispersion used in Dorman's program PV7 referenced by McEvilly (1964) and Mooney & Bolt (1966).

INV3 was translated into Algol for running on the Elliot 503 computer (8K random access store) available at the University of Tasmania. Several modifications were made.

(1) The earth flattening approximations of Alterman et al (1960) were added to allow inversions of the M_{21} Rayleigh mode phase

velocities. This increases the shear and compressional velocities of layers according to the following formula

$$v_h = v_f \ (1 + d/R)$$

v_h = modified compressional or shear velocity in layer

v_f = assigned velocity in the flat layer model

d = depth to mid point of the layer

R = Earth radius

This increase in velocity compensates for the smaller travel path for portions of deeply penetrating waves in the real earth.

These adjustments were made before calculating the model phase velocities and partial derivatives in each iteration. Corrections from the solution of normal equations were applied to the flat-layer model velocities and final solutions given in terms of such a model.

(2) The matrix inversion sub-routine of INV3 was replaced by a faster "forward and back substitution method" of solving symmetric positive definite matrices.

The set of simultaneous equations

$$\sum_{i=1}^{n} \frac{\partial c}{\partial p_i} dp_i = dc_j \qquad \text{(see section 2.2.5)}$$

may be written in matrix form

$$[A].[x] = [b]$$

where x is the column vector of corrections, dp_i, to n model parameters p_i.

b is the column vector of observed minus computed model phase velocities dc_j at m period points

A is the n x m matrix of sensitivity coefficients $\partial c/\partial p_i$.

Thus $A'Ax = A'b$

and $Cx = d$

is the set of normal equations, where $C=A'A$ and $d=A'b$

The matrix C is symmetric positive definite and can be decomposed into $U.L$ where $U=L'$ is a triangular matrix.

i.e. $U.L.x = d$

Substituting $y=L.x$, y can be found by successive substitution and then x by back substitution.

(3) Sections of the Haskell-matrix subroutines leading to evaluation of the characteristic determinant were rewritten to achieve higher speed of execution in Algol. This involved mainly replacing arrays with variables where practical and reformulating one small segment in Elliott Algol machine code instructions.

(4) Calculation and listing of Poisson's ratio for each layer was added. With these modifications to the program, moderate problems involving 5 to 8 layers with say 5 active parameters and 15 to 20 observed period values required 15 to 20 minutes to complete 5 iterations.

2.2.7 Interpolation of Model Solutions

Model solutions for dispersion profiles related only by differences in source phase constitute a special set. Profiles differ by velocity increments proportional to period, T.

Because the source phase and phase increment are arbitrarily chosen, computed profiles will not necessarily coincide with the correct dispersion for a given waveguide, which will then be straddled by two profiles, say I and II selected as described in 2.2.3 (b).

Provided the partial derivatives $\partial c/\partial p_i$ are identical for models fitting I and II, a third model to match the intervening profile, III, can be found by interpolation. This can be inferred from the matrix reduction in section 2.2.6.

Let $[X_1]$, $[X_2]$, $[X_3]$ be sets of parameters for models matching profiles I, II, III and $[x] = [X_2] - [X_1]$, a column matrix of differences.

$[A]$ is defined as the matrix of partial derivatives as in 2.2.6 and is identical for models I and II, at least to the order of accuracy necessary to specify the parameters.

$[\delta_{12}]$ and $[\delta_{13}]$ are column matrices of phase velocity increments separating profiles I, II, and I, III respectively.

Then $[\delta_{13}] = k\,[\delta_{12}]$, k = constant

Hence $k[x] = k\left([A]'[A]\right)^{-1}[\delta_{12}] = \left([A]'[A]\right)^{-1}[\delta_{13}]$

and $[X_3] = [X_1] + k[x]$

Therefore models derived from profiles above and below the correct profile define upper and lower limits on the parameters of the model corresponding to the correct profile.

2.2.8 Mantle Densities

Throughout this investigation, numerical values of density, employed in various earth models, were kept fixed.

This section briefly reviews the kind of information now available on the likely density below the Moho and the density profile of the upper mantle. Rather than summarise the evidence, the intention is to mention the various types of approach employed and state the choice of density profile made. The reason for this is twofold:

(1) No upper mantle density measurements have so far been made.

(2) Upper mantle density profiles may vary widely on a regional basis and conclusions reached about the morphology of the profile in some regions may not apply to New Guinea.

I have already mentioned that phase velocity interpretations are based on the inversion procedure and while it is numerically feasible to "float" layer densities, the results have little meaning when both densities and shear velocities within the same layer are varied together. This can be

overcome if Love wave dispersion data are available, provided the waveguide "layers" have homogeneous isotropic characteristics. These data reveal the shear velocities which are then fixed in the Rayleigh wave problem to find densities. McEvilly (1964) suggests that anistropy exists in some regions however.

In the absence of suitable data from which density can be directly found, one can examine "average" density profiles determined for the earth as a whole. Sensitivity $\partial c/\partial \rho$ is usually sufficiently small that permissible departures (physically) from such a profile will not seriously affect the fit of the model.

St. John (1964), in his analysis of the gravity field of New Guinea, assumed a density contrast of 0.5 gm/cc at the crust mantle boundary throughout the New Guinea mainland, and found that this afforded a geologically and tectonically sound interpretation.

Brune and Dorman (1963) employed the Bullen model A density profile in their CANSD model. Density increases steadily with depth, from 3.30 just beneath the upper mantle, reaching 3.60 at about 300 km. Reviewing this profile, Thomsen (1967), using thermodynamic arguments suggested this gradient might be too high if the accompanying shear velocity profile followed a similar trend to the Gutenberg distribution. Thomsen preferred the density profile suggested by Bullen & Haddon (1967), having a slightly smaller density increase with depth. It is interesting to note that Thomsen did not rule out a density inversion in the upper mantle, a possibility now receiving some attention for other reasons.

An entirely different approach has been made by Clark and Ringwood (1964) on mineralogical grounds. They discuss some preferred density profiles assuming a primary mantle material of eclogitic ($\rho \approx 3.5$) or "pyrolitic" ($\rho \approx 3.3$) composition, preferring the latter as a model. Subsequently Ringwood and Green (1966) advanced further argument opposing the existence of a primary eclogitic composition for the upper mantle.

However a recent study by Press (1968a,b) involving a search for earth models to fit a comprehensive set of seismological data including free oscillations up to the 105th mode, has reopened the possibility of an average upper mantle density of about 3.5 especially beneath the oceans. An earlier study by Pekeris (1966) sought density models for several velocity profiles to fit the first 48 modes of the free oscillation. The density profiles found favoured a "sub-Moho" value of 3.4 or more.

In this study I have adopted interpolated densities from the Bullen & Haddon (1967) profile. This is consistent with the local gravity interpretations for the upper mantle density of 3.32 and meets the thermodynamic tests of Thomsen (1967) subject to a velocity profile of the Gutenberg type. Brooks (1962) demonstrated in a general way the likelihood of this being so for the New Guinea region.

2.2.9 Poisson's Ratio

This parameter is used as a criterion to interpret inversion data to determine an optimum value of crustal thickness in a two layer system. One must seek, therefore, some information about values of Poisson's Ratio (σ) to be expected in the crust and upper mantle.

Molotova and Vassil'ev (1960) have summarised a wide range of field observations of P and S velocities which indicate a general range in σ from 0.22 to 0.27 for depths 5 km to 30 km although there is no suggestion of a depth dependence. Estimates for a crustal average ranged from 0.23 to 0.26.

In addition there have been numerous studies of velocities on laboratory samples of a variety of rocks at high pressures e.g. Birch (1960, 1961) measured P wave velocities and Simmons (1964a,b) measured S wave velocities at 10 Kb. Kanamori and Mizutani (1965) measured both velocities up to 10 Kb for peridotitic, gabbroic, eclogitic and granitic rocks. They suggest a $\sigma \leq .30$ for a peridotitic upper mantle, preferring $\sigma \approx 0.27$ and infer a possible negative correlation between α and σ. On the other hand granitic rocks were

found to have a range for σ of 0.25 to 0.33.

More recently, Volarovitch and Galdin (1968) have given some data at lower pressures (5000 Kg/cm^2) with quite consistent results with $\sigma \approx 0.25$ to 0.27 for α = 6 to 7 km/sec.

Alexander (1963) established that "Poisson's Ratio departs significantly from the value of 0.25 usually assumed in the crust" for the Basin and Range province of western U.S.A. suggesting that it may be as high as 0.30 for the lower crust (case 35CM2).

It may be concluded from these studies that a range in σ for the crust from 0.23 to 0.30 would be consistent with both the experimental and field evidence available now.

According to Kanamori and Mizutani (1965) a $\sigma \approx 0.27$ is acceptable for a peridotitic upper mantle, and $\sigma \approx 0.30$ for an eclogitic upper mantle.

2.3 ERRORS

2.3.1 Path Length and Origin Time

(a) Magnitude of Errors

In section 2.2.3 a method was suggested whereby, subject to sufficiently small errors in r and t, ϕ_0 could be established to within $\pm \frac{\pi}{4}$. In section 2.2.7 it was argued that, subject to certain conditions, limits on model parameters could be defined in this way.

In this section, the errors in r and t are examined and their effects on profile groupings discussed.

Phase velocities determined from single station data reflect errors in epicentral location through the formula

$$C = r/t$$

t has several components but I consider here only errors in origin time.

Hence $$|\Delta C/C| = |\Delta r/C.t| + |r\Delta t/Ct^2|$$

where Δr = epicentral distance error

and Δt = origin time error (receiver timing errors are sufficiently small to be ignored)

Freedman (1967) estimated an average magnitude of source parameter errors. She concluded that standard errors of $\Delta r \approx 0^{\circ}.5$, $\Delta t \approx 4$ sec. were possible for 1962-63 data, although there was some evidence to suppose these to be smaller for more recent data. Brooks (1962) suggested $\Delta r \approx 1/4^{\circ}$ for New Guinea epicentres in 1960, 61. Current ESSA earthquake data reports suggest accuracies of "a few tenths of a degree".

The maximum influence of such errors on C is shown in Table 2.

TABLE 2

Percentage error estimates in phase velocity due to various errors in epicentral parameters for C = 4 km/sec.

r	d	$\Delta r/Ct$	Δt	$r\Delta t/Ct^2$	$\Delta C/C$		$\Delta\phi_o = \pi/2$	
(km)	(km)	%	(Sec.)	%	%	km/sec.	T	dc
1000	50	5.0	4	1.6	6.6	0.26	50	.18
	25	2.5	2	0.8	3.3	0.13	25	.10
	10	1.0	1	0.4	1.4	0.06	10	.03
500	50	10.0	4	3.2	13.2	0.53	50	.35
	25	5.0	2	1.6	6.6	0.26	25	.18
	10	2.0	1	0.8	2.8	0.11	10	.05

The temporary recording stations used in this study did not contribute data for the epicentre solutions used, and so I have assumed that errors in these solutions are not correlated with the azimuths of source to station paths.

Having regard to sign, standard errors of, say, $\frac{1}{4}^{\circ}$ and 4 seconds in epicentre and origin time, will cause corresponding "average" variations of

about $1/8^{\circ}$ in path length and zero seconds in travel time. Paths with azimuths in quadrants containing, or opposite to, the displaced epicentre will vary accordingly, while those in the remaining two quadrants will be little affected. It is also assumed that errors in origin time will be equally distributed as regards sign.

On the above basis and using the figures given in Table 2, I take Δr = 10 km and Δt = 1 second as appropriate "average" errors in epicentre and origin time, and expect accumulated corresponding errors in phase velocity of about 0.06 km/sec. and 0.11 km/sec. for path lengths of 1000 and 500 km respectively.

Separation of profiles corresponding to $\Delta\phi_o = \pi/2$ are given in the last column of Table 2. These exceed the "average" errors of .06 and .11 by a factor of 2 for periods longer than about 30 sec. Hence identification of separate profile groups should therefore be possible in this longer period range.

Larger average errors in r and t would produce an obvious "smearing" of groups of profiles for events having paths of about the same length. This should be normally evident for periods below 30 sec. or so, a limit which therefore depends on the errors in a particular set of observations.

(b) Shape of Profiles

Families of such "single station curves" (section 2.2.2) will exhibit two kinds of scatter

(a) due to errors Δr and Δt

(b) due to errors in ϕ_o, where this is assumed to be $\pm n\pi/2$

Errors of type (a) will cause displacement of the dispersion curve by an amount ΔC which depends on C rather than T. For example, using model 117, Appendix 2 as a guide, C varies between 3.4 and 4.0 km/sec. in the T range 20 to 50 sec. If $\Delta C/C$ = 3%, ΔC varies from .12 to only .10 over this T range i.e. an almost parallel displacement. Errors of type (b) are proportional to T and tend to produce a "fan shaped" scatter about the true profile.

Thus families of single station profiles will be scattered rather than coherently grouped if errors of type (a) are significant. Such scattering is distinguishable in the profile shape, from the uniform spreading of profiles which occurs if type (b) exist.

2.3.2 Variation of Initial Phase with Period

Although the frequency dependence of ϕ_o influences both group and phase velocities, it has not so far been taken into account in studies of either because too little is known about the nature of earthquake source parameters. Most investigations have been content to assume an impulse type source or a displacement step. Recently Knopoff and Schwab (1967) deduced some relations between frequency and initial phase assuming a line source at an inclination of 45°, and a particular geometrical waveguide configuration. For fundamental mode Rayleigh waves, they found that

$$\frac{1}{C} = \frac{1}{\bar{C}} \pm (.0832T - 2.07)/r$$

where C = correct phase velocity ($r = \infty$), in km/sec.

$\bar{C}$ = measured phase velocity

r = epicentral distance, in km

T = period, in seconds

For the path lengths of 1500 km or so, the resulting correction, although not necessarily a maximum, amounts to $\pm$ .02 km/sec. for T = 50 sec., and less for shorter periods. The mean observed scatter of the fundamental mode observations in this study, as shown above, is of this order, or more. Corrections to group velocity were even less significant, those required for the 1st higher Rayleigh mode appearing to be greater, but still close to the limits of observational errors for path lengths of 1000 to 2000 km employed here. No attempt was made to apply these corrections to the New Guinea data.

2.3.3 Variation of Initial Phase with Mode Number

If a single source generates Rayleigh wave motion in more than one mode, it is necessary to enquire whether or not ϕ_o is mode dependent as well as frequency dependent.

Ben-Menahem and Harkrider (1964), and Harkrider (1964), devised expressions from which the source phase dependence on mode number can be calculated in terms of the Haskell (1953) layer matrices.

Source phase, from equation (25) of Ben-Menahem and Harkrider is

$$\phi_o = \tan^{-1}\left\{ \frac{d_1 \sin\theta + d_2 \cos\theta}{d_o + d_3 \sin 2\theta + d_4 \cos 2\theta} \right\}$$

where θ = azimuth relative to the fault strike direction, $d_o \ldots d_4$ are functions of the source geometry and depend on the horizontal and vertical displacement ratios at the source depth and at the surface, and the elastic constants of the source medium.

There is no explicit relationship between ϕ_o and mode number for the general case since the displacements which are involved vary with the structure and the mode number.

Ben-Menahem and Harkrider evaluated ϕ_o for only one Rayleigh mode, but Harkrider's (1964) findings - see Appendix I(b) - were more general. It would appear that provided the horizontal to vertical displacement ratios at the source depth, and the ratio of vertical displacement at the source depth to that at the surface, remained the same for both modes, the source phase in a given azimuth is probably the same for the fault type source. These ratios however are strongly period dependent, especially for the second and higher modes.

The evaluation of initial phase as a function of mode number therefore required an hypothesis concerning source mechanism and model details, a field of investigation which is both beyond the scope of this thesis and pointless at this stage of knowledge concerning earthquakes and earthstructure in the New Guinea area.

However, the restrictions on a fault source, implicit in the hypothesis of constant initial phase, independent of mode, invariant with frequency, with an uncertainty of $\pm n\pi/2$ are obscure. In Chapter 3 displacement profiles are computed for one model to provide data for a future study of this problem.

2.3.4 The Time Window

The use of near earthquakes in this study meant that the data were recorded within only small time windows of from about 3 to 10 minutes duration.

The spectral analysis of a time domain recording of a Rayleigh wave is seldom straightforward. Usually, contamination by superimposed body waves, Love waves, delayed Rayleigh waves or surface waves of modes other than the target mode occurs to some extent. These effects are smallest for long, structurally uniform, wave paths (which are best adapted for investigation by surface wave methods), and can be arranged into at least four general categories.

1. The target and contaminating frequency ranges do not overlap. Analysis is straightforward, phase velocities emerging from a direct interpretation of the Fourier spectrum although digital filtering with a fixed bandwidth filter is often desirable to clarify the useful portion of the record, and is necessary to permit a time domain group velocity analysis.
2. The target and contaminating frequency ranges overlap, the form of contamination is unknown, and unrelated to the target data which cannot then be extracted.
3. The target and contaminating frequency ranges overlap, with contamination taking the form of a delayed primary signal e.g. superimposed Rayleigh waves arriving along different paths, having similar transfer functions.

Pilant and Knopoff (1964) have discussed several variations of this form of contamination. In the simplest case where the waveforms were similar and the delay large enough, they successfully separated the

primary event using a variable (time dependent) bandwidth filter before examining the Fourier spectrum. For this method to be successful the characteristics of the interfering signal must be known approximately and used to control the filter parameters. (Pilant and Knopoff, 1964).

4. Characteristics of the contamination are largely unknown. Many records of this type are not useful, but in some cases a portion of the (apparently) uncontaminated Rayleigh wave may be evident on the record. If the record is truncated, the Fourier spectrum of the portion kept is a modified form of the true spectrum.

Two methods were devised (Appendix II) to assess how the choice of the time window influenced the computed phase velocities.

Method 1: A series of test evaluations of phase velocity from truncated synthetic seismograms was conducted. This method gave consistent results indicating that the low group velocity termination of the time window should be about 2.2 km/sec. or less for the fundamental mode.

Method 2: A quasi-analytical approach employing a dispersed wave $y(t; x)$ having the spectrum given in Appendix II (b) - equation (3). A general expression for the spectrum of a truncated dispersed wave of this basic form was developed and a program written to evaluate phase velocities for a range of truncating time windows. The method was unsuccessful, the reason probably relating to the approximations involved in the original expression $y(t; x)$. However the approach is thought to be novel, and a summary of the development has therefore been included in the Appendix.

2.3.5 Lateral Heterogeneity

The perturbing influence of lateral structural inhomogeneities, not recognised in the early work of Evernden (1954) and Press (1956) was first revealed by Pilant and Knopoff (1964) who disclosed the form of spectral modulation caused to a dispersed primary wavetrain by a delayed secondary wave having similar characteristics. Where the delayed wave was

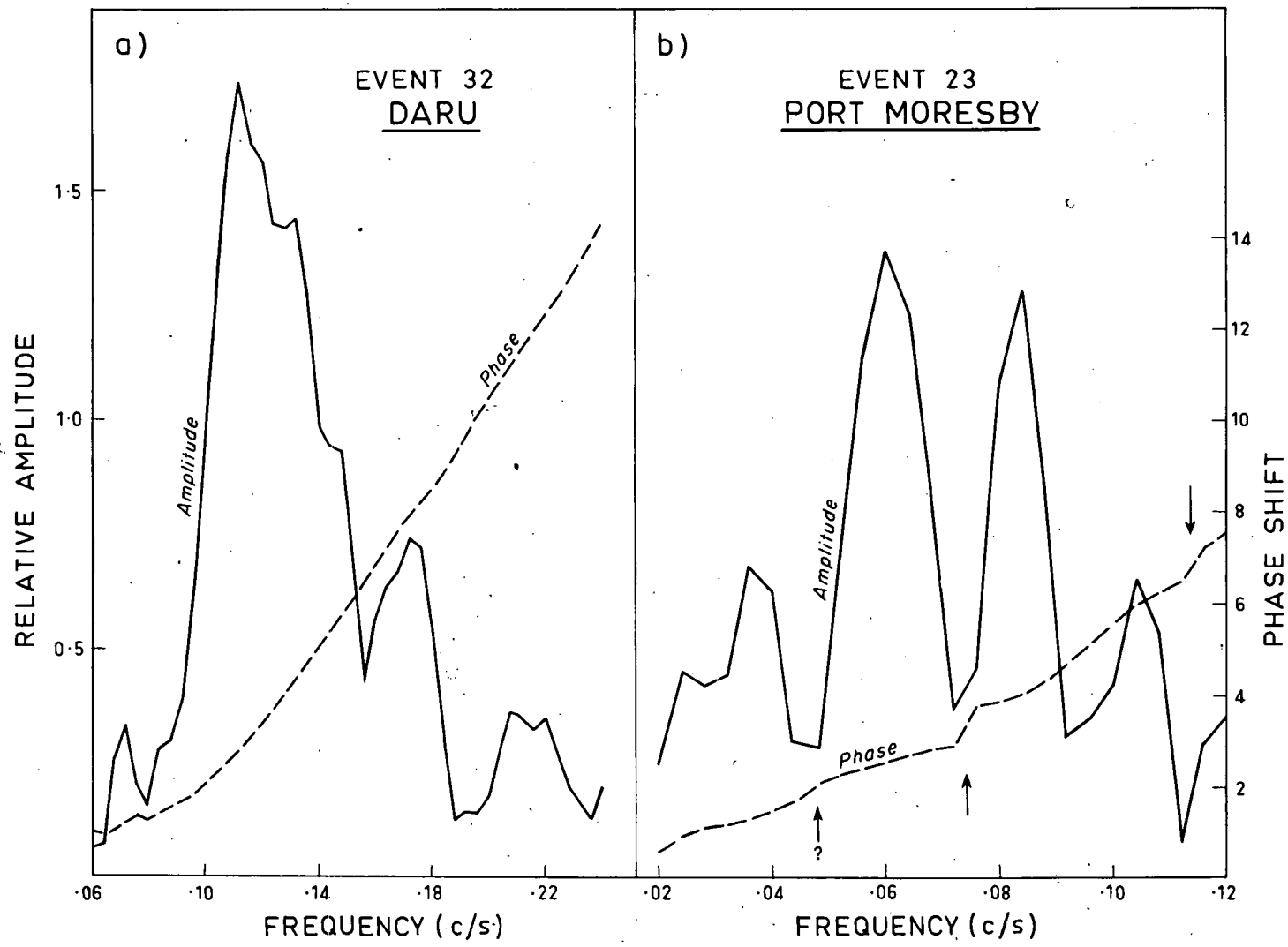

FIG. 8 FOURIER SPECTRA OF UNPERTURBED (a) AND PERTURBED (b) WAVETRAINS, RECOGNISED BY PRONOUNCED PHASE IRREGULARITIES INDICATED BY THE ARROWS

PNG/B9-51

(Based on G82/2-83)

a "back reflection", Knopoff and Mal (1967) showed theoretically that the dispersion curve (for Love waves) was modulated in an oscillatory manner. In the time domain, these perturbations are easily recognised by the appearance of beats, or in fact, most cases of non smoothly-varying amplitude with time (stationary groups excluded). In the frequency domain a non smoothly varying phase angle with frequency is characteristic. Figs. 8a,b show this for two New Guinea events.

Fig. 9 shows phase velocities for events 13 measured at Tapini. The oscillatory modulation is attributed to back reflections from the thinning crustal waveguide south of the station. Much less perturbation is revealed by the Port Moresby record of the same event. Velocities from event 6, a source very close to 13, but occurring 5 months earlier, are also shown. Close agreement between these two dispersion curves demonstrates a high degree of reproducibility even in such a structurally complex waveguide.

The influence of lateral heterogeneity on phase velocities measured across a tripartite array was studied by Knopoff, Berry and Schwab (1967). These are reliable only when the wave vector almost coincides with one leg of the array and velocities relate to structure beneath this leg. Essentially this means that only "two station (or "single" station) methods are applicable in laterally heterogeneous regions. Errors of this kind were responsible for restricting the tripartite data from teleseismic sources that were recorded in New Guinea, to few events only, and some of these cases were affected by back reflections. This contributed to the change of emphasis of the investigation to a study of near earthquakes (see introduction). For the nearer sources the tripartite approach was in any case less reliable as wavefronts were no longer plane although appropriate geometric corrections for this are possible (Luosto, 1965). The more serious effects of secondary wave interference, removed in the European data by Pilant and Knopoff with the time dependent variable bandwidth ("moving") digital filter, could not be processed out of the New Guinea data because

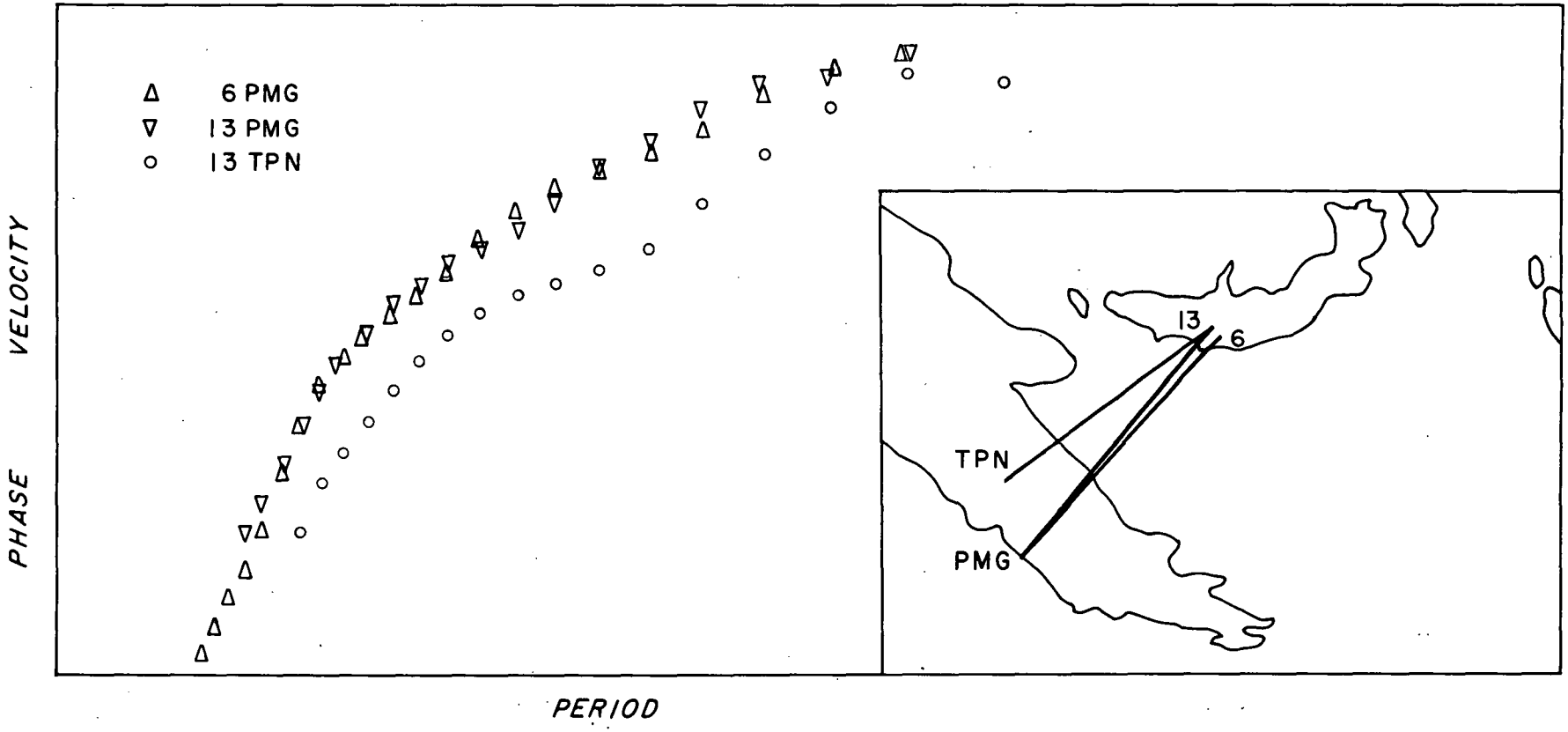

FIG. 9 RELATIVE PHASE VELOCITY DISPERSION PATHS 6, 13 TO TPN AND PMG ILLUSTRATING MODULATION BY BACK REFLECTION FROM THINNING CRUST

PNG/B9-41

(i) the data time windows were short in comparison to the periods of interest (See Appendix III)

(ii) delays (sometimes from multiple interference) were small.

The data for final analysis were therefore selected from those with smooth phase transforms and smooth dispersion curves. The risk of "over-processing" was thus avoided and velocities presented for interpretation here are calculated directly only from the digitised original waveforms.

In this study, the smoothest dispersion profiles were found for southern New Guinea and the Solomon Sea, and hence one expects the model parameters to approximate reality best for these regions.

2.3.6 Anisotropy

Velocity anisotropy is difficult to distinguish unless both Love and Rayleigh waves are available for study. In studies of southern New Guinea structure made here, the first two Rayleigh modes are employed. It will be shown in Chapter 3 that a single model structure was not found, for which theoretical dispersion exactly matched observed data in both modes. Mismatch was greatest for particular period ranges at which phase velocities are strongly influenced by the uppermost 50 km of structure just beneath the M discontinuity for each mode.

The ratio of horizontal to vertical displacement varies with depth in a different manner for each mode, as does the phase velocity sensitivity, $\partial c/\partial \beta$. If β_x and β_z are not identical, mismatch between modes may be a consequence of assuming isotropy in the structural section concerned.

The alternative possibility remains however, that mismatching might equally well be explained by the necessity to employ a relatively coarse structure consistent with the data (see section 2.2.5). Examination of a very finely layered structure is precluded by the range of wavelengths, and low modes considered here. The problem of existence of velocity anisotropy has therefore not been resolved.

3. SOUTHERN NEW GUINEA

3.1 GEOLOGIC AND TECTONIC SETTING

Southern New Guinea, (Fig. 10), can be classified as a shield area. It extends from the Bomberai Peninsula in West Irian, southeast, to the Gulf of Papua, which is included in this analysis. It is bounded to the north by the deepening sediments of the southern marginal elements of the Papuan Geosynclinal system, and to the west by the submarine escarpment, west of the Tanimbar - Kei group, at the eastern end of the Banda Sea.

The region comprises a southern platform, tectonically stable at least since pre-Mesozoic time, marginal to the Papuan Geosynclinal system which began to form in the early Mesozoic (Smith, 1964). Smith has reconstructed the subsequent tectonic development of the Papuan Geosyncline. St. John (1967) made a detailed analysis of the regional gravity field in terms of near surface geology and related his findings to the tectonic development of the whole New Guinea region.

A number of cores (Fig.10) have provided good post Mesozoic stratigraphic data, which were reviewed by Visser and Hermes (1962) for cores in West Irian. Compressional velocities of 'basement' formations have been determined from exploration refraction profiles at rather scattered localities.

Visser and Hermes (1962) reported compressional velocities exceeding 4 and 5 km/sec. in the Kariem formation at Merauke and Oeta, at depths of 1 to 2 km. They regard this formation as probably of Cambrian age although Smith (1964) is inclined to doubt the correlation by Bar et al (1961) of this group with the Upper Cambrian Georgina series of Northern Australia, suggesting Jurassic as a more probable age.

Visser and Hermes (1962) identify the basement beneath the Oeta

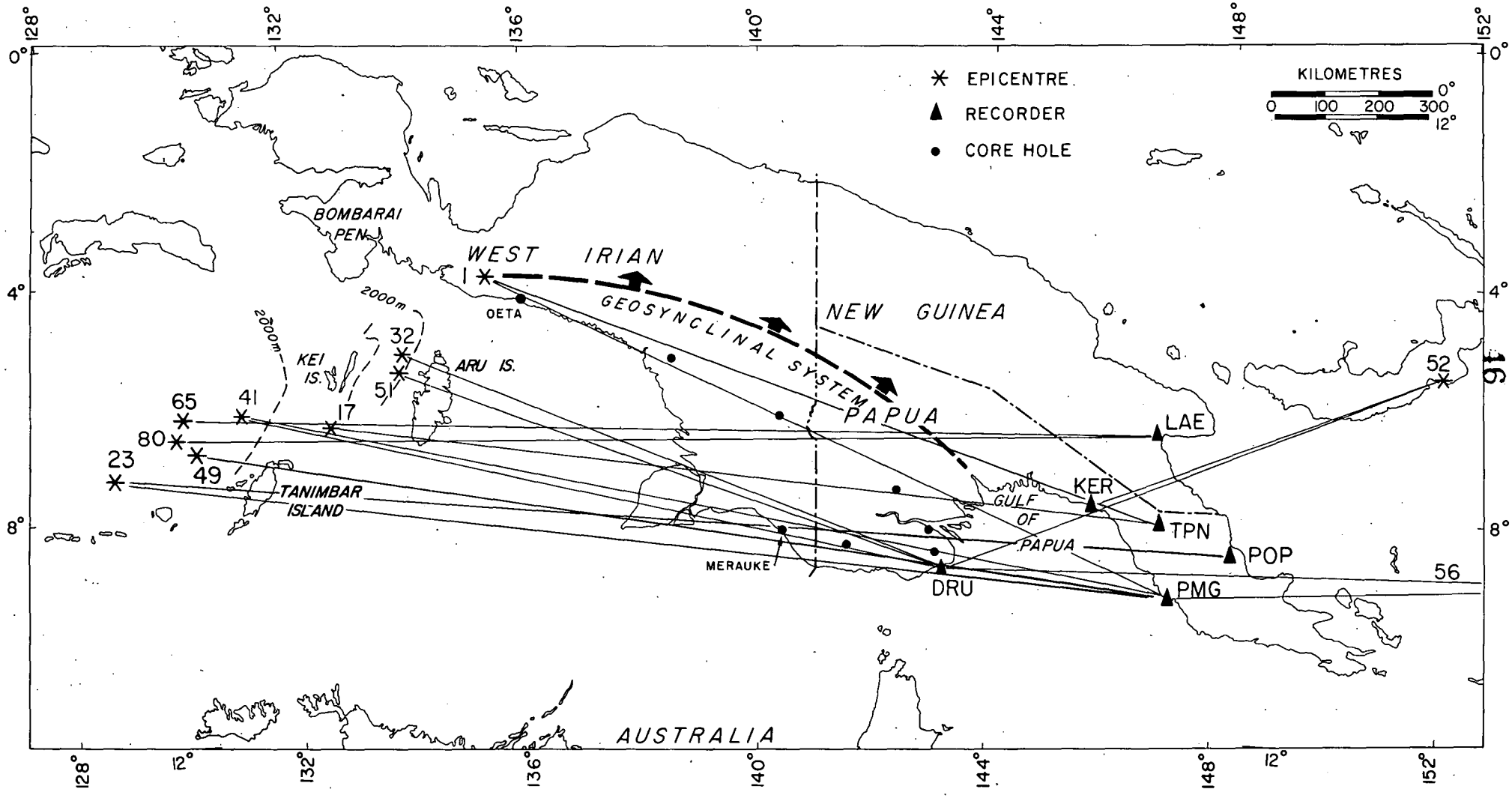

FIG. 10 SOUTHERN NEW GUINEA EPICENTRES, PATHS AND CORE LOCATIONS.

core (Fig. 9) as Precambrian and report corresponding compressional velocities of 5.8 km/sec.

Possible genetic relations between the platform regime and the three principal geologic units of Northern Australia have been discussed by Carey (1938), Glaessner (1950) and Visser and Hermes (1962). These units are:

(a) The Precambrian Shield.

(b) The Mesozoic sediments of the Great Artesian Basin which extend to the Gulf of Carpentaria.

(c) The Tasman Geosyncline.

The existing evidence and interpretations favour a shield structure for southern New Guinea, although the geological control is not strong.

The Bouguer anomaly maps of St. John preclude a connection with (b) unless the density of the sediments is indistinguishable from deeper basement. Visser and Hermes regard a relation with (c) as unlikely on stratigraphic grounds and it also seems remote from gravity considerations.

Smith (1964) has qualitatively interpreted the history of vertical oscillatory movements in Western Papua and New Guinea since the early Mesozoic (Smith, 1964, Chapter 4.2) from which summary the very stable characteristics of the Fly-Digoel platform regime provide a marked contrast with other New Guinea structural units.

So far as can be deduced from the near surface geology, southern New Guinea forms an ideal environment in which to apply analytical methods of surface wave seismology which require the waveguide to approximate a uniform horizontally layered structure.

The post Mesozoic superficial geology will influence surface wave velocities at short periods although this influence will be small for the thin formations overlying crystalline basement. These range in age from Jurassic to Recent and in type from massive basal limestones with compressional velocities from 2 to 5.4 km/sec. to mudstones, shales and clay

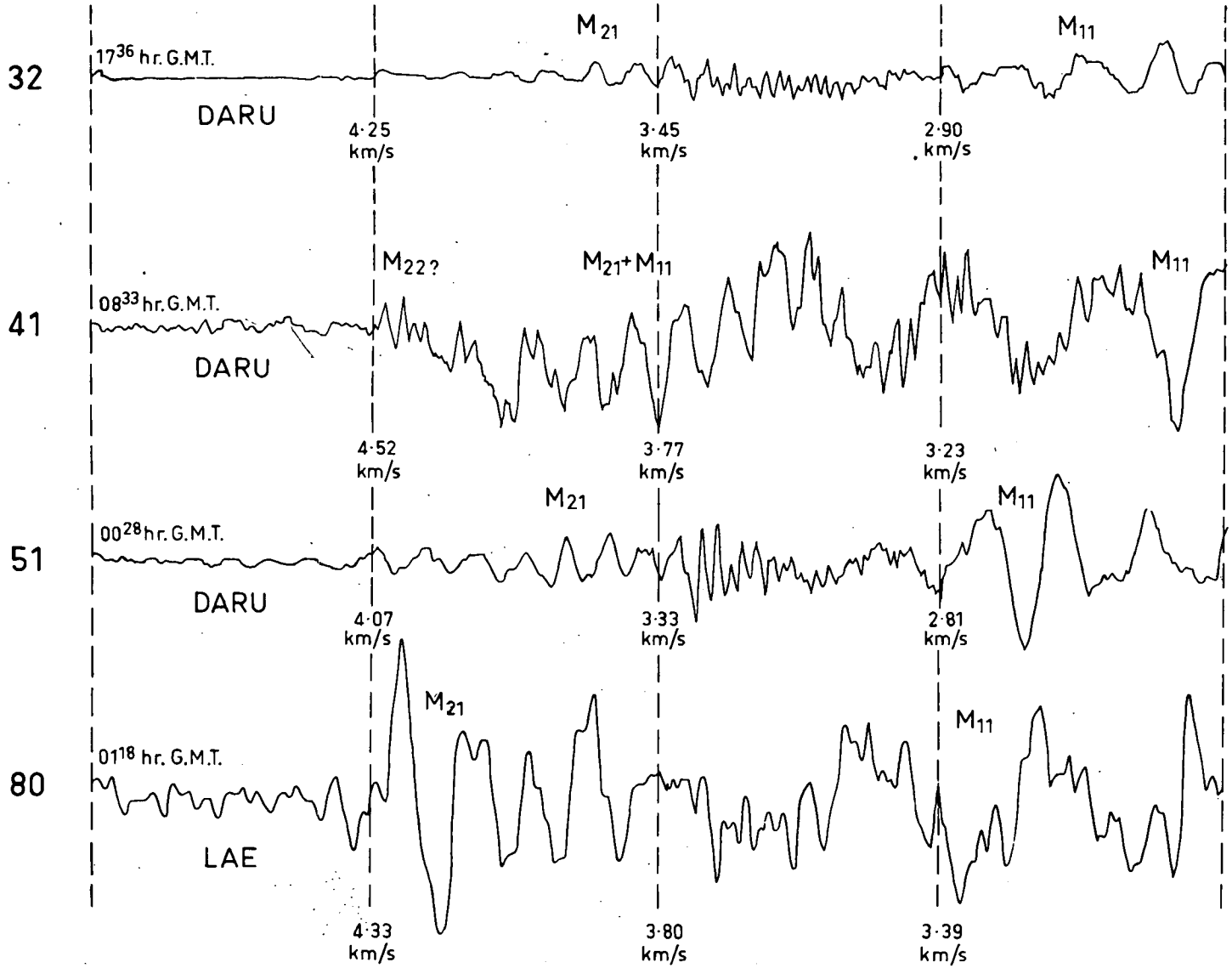

FIG. 11 SEISMOGRAMS OF SHALLOW FOCUS EARTHQUAKES SHOWING WELL DISPERSED HIGHER MODES. GROUP VELOCITIES ARE MARKED AT I MINUTE INTERVALS

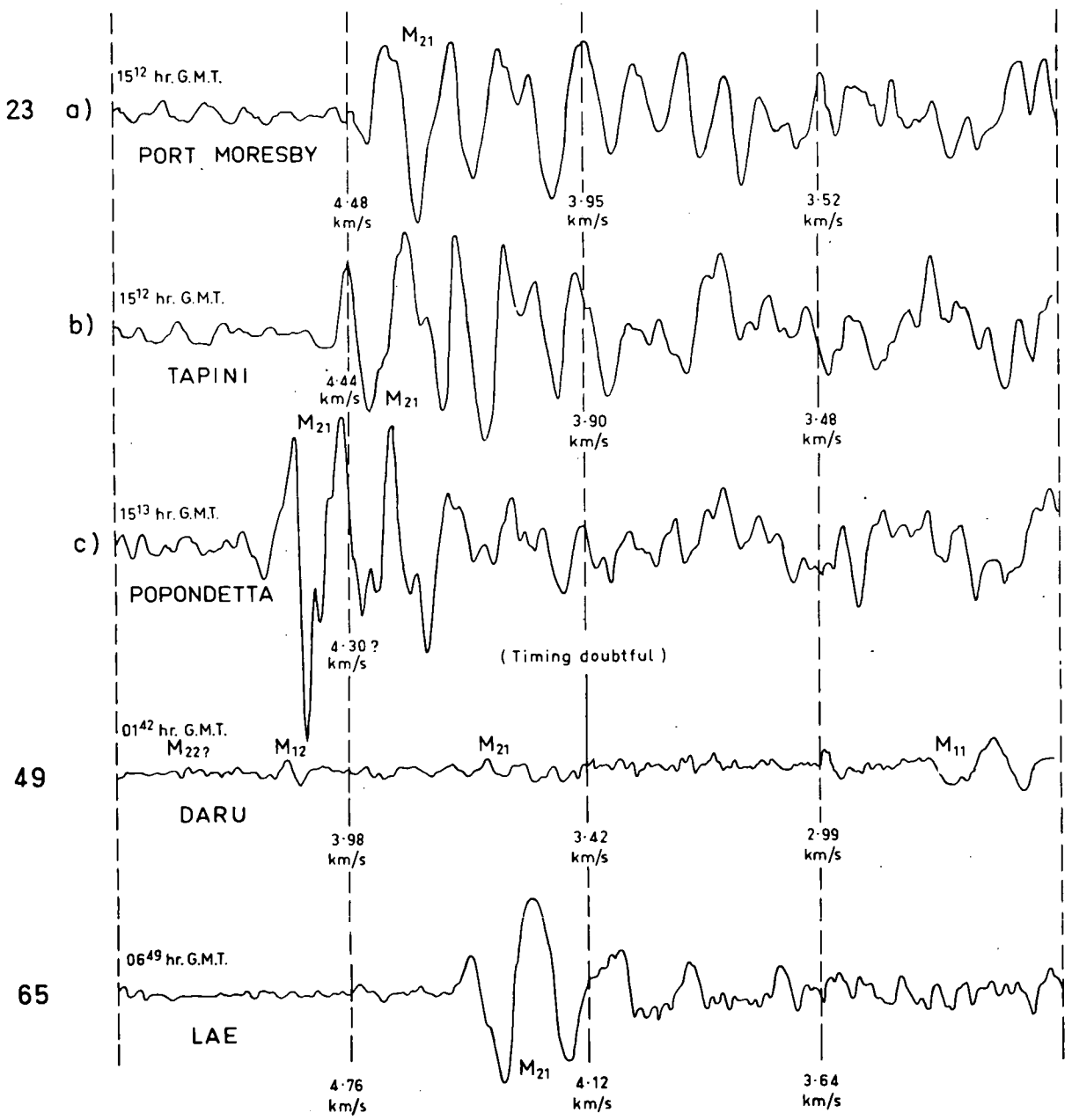

FIG 12 SEISMOGRAMS OF DEEPER FOCUS EARTHQUAKES SHOWING LARGE AMPLITUDE STATIONARY GROUPS.

formations. The following parameters representing a superficial crustal layer have been adopted on the basis of stratigraphic data culled from the various core log reports by Visser and Hermes (1962) and St. John (1967). The thickness was estimated from core holes marked in Fig. 10 and probably apply most directly to paths from the Aru Islands to Daru.

Thickness	Compress. Veloc.	Shear Veloc.	Density
2.0 km	4.0 km/s	2.3 km/s	2.3 gr/c.c

3.2 OBSERVED DATA

Earthquake details and path data for events employed to interpret southern New Guinea structural data are given in Table 3 and Fig. 10.

3.2.1 Identification of Modes

The fundamental Rayleigh mode (M_{11}) is clear.

The identification of the second Rayleigh mode (M_{21}) is more difficult, especially as only single component records were available. These are displayed in Figs. 11, 12. They are arranged into two categories according to focal depth.

Fig. 11 - events 32, 41, 51, 80 having focal depths of 100 km or less

Fig. 12 - events 23, 49, 65 having focal depth greater than 100 km.

Group velocities have been marked along the time axis of each seismogram, on all records except 23 (POP) for which timing was uncertain.

Interpretations are marked on Figs. 11 and 12.

All events in Fig.11 show at least two distinct wave trains with clear dispersion. The longer period fundamental mode is prominent towards the later portion of the records. The range of group velocities and periods covered by the remaining group is consistent with those of the second

TABLE 3

Earthquake Source Data

EVENT	ORIGIN G.M.T.	LAT (°S)	LONG (°E)	DEPTH (KM)	MAG. U.S.C.G.S.	STATION	Δ KM	AZ (°)	MODE
1 Jan 23, 1965	16 09 01.4	4.1	135.3	34	5.3	TPN	1367	110.6	M_{11}
						PMG	1426	114.7	
17 Feb 13, 1966	06 35 55.7	6.6	132.6	12	-	TPN	1589	97.9	M_{11}
23 Nov 20, 1965	15 05 39.0	7.3	129.0	132	6.6	PMG	1978	98.0	M_{21}
						TPN	1952	94.6	
						POP	2092	95.6	
32 Mar 2, 1966	17 32 42.6	5.4	133.9	50	5.3	DRU	1098	112.2	M_{11}, M_{21}
41 May 25, 1966	08 28 58.6	6.4	131.1	39	5.8	DRU	1359	103.3	M_{11}, M_{21}

EVENT	ORIGIN G.M.T.	LAT (°S)	LONG (°E)	DEPTH (KM)	MAG. U.S.C.G.S.	STATION	Δ KM	AZ (°)	MODE
49 July 8, 1966	01 37 55.2	6.9	130.2	113	5.5	DRU	1444	100.4	M_{21}
51 Aug 8, 1966	00 24 27.0	5.7	133.8	15	-	DRU	1096	110.4	M_{21}
52 Aug 10, 1966	12 33 42.2	5.5	151.8	40	5.3	KER	715	247.5	M_{11}
						DRU	1022	246.8	
56 Sept 7, 1966	05 53 45.7	8.7	156.5	52	5.3	PMG	1024	264.9	M_{11}
						DRU	1177	273.2	
65 Feb 18, 1967	06 43 31.2	6.4	130.1	159	5.0	LAE	1848	91.9	M_{21}
80 Mar 19, 1967	01 10 45.8	6.7	129.9	60	5.9	LAE	1869	90.9	M_{21}

Rayleigh mode, M_{21}, with waves in the period range 5-15 sec. having group velocities from 3.3 to 4.3 km/sec. showing strong dispersion. By contrast the third (M_{12}) Rayleigh mode can be expected to show group velocities above 4.0 km/sec. for most of this range for both Jeffreys-Bullen and Gutenberg-Birch velocity structures, with more likelihood of stationary groups than M_{21} (Kovach and Anderson, 1964). The fourth (M_{22}) mode may be represented by the isolated stationary group on event 41 at T 3-4 sec., U 4.5 km/sec.

The deeper focus records in Fig. 12 all exhibit the features of stationary groups. Apart from event 49, large amplitude motion with a relatively sudden onset at group velocities of about 4.3 km/sec. occurs in the period range 10-25 sec. on all records. Three component records from the WWSSS equipment at Port Moresby are available for events 23 and 65 and reveal that this motion has a strongly vertical component. Analysis of particle motion was prevented by interference on the east-west component.

Strong SV type waves at these periods and velocities have been identified as Sa (channel) waves in the literature. Anderson (1966) proposed the term Ma, to distinguish SV from SH type motion. Bath and Arroyo (1963), and Brune (1965), have discussed the characteristics and possible interpretations mainly for long paths. Both find significant velocity differences between continental and oceanic paths and Brune found velocities of around 4.3 km/sec. appropriate for tectonically active areas, and which might therefore be expected for the New Guinea paths.

The complexity of some Sa observations has partly been attributed to regional upper mantle variations, but is unlikely to be so for these short New Guinea paths.

There is now considerable agreement that most channel waves can be explained as higher mode surface waves, particularly their group velocity maxima and minima (Airy Phases), e.g. Kovach and Anderson (1964), Brune (1965), Anderson (1966). This interpretation is followed here.

Bath and Crampin (1965) doubted the association with Airy phases but their studies covered a more restricted period range (5-15 sec.) than the present investigation.

Apart from "pure" higher mode propagation, at least two forms of "hybrid" higher mode waves have been discussed by Crampin (1966, 1967).

Reflection and refraction effects, in areas of non-uniform structure, will further complicate the interpretation of stationary groups on the seismograms.

Although magnitude differences preclude accurate comparisons of amplitudes between earthquakes, it is instructive to consider briefly the relative amplitude of different modes within each record.

The largest amplitudes for $U > 3$ km/sec. on event 49, is displayed by the M_{12} stationary group. Kovach and Anderson (1964) reviewing profiles of displacement as a function of depth for this mode, demonstrate that a large amplitude lobe spans the region of lowest shear velocity. Accordingly this is indicated, beneath southern New Guinea, in the region of the focal depth of event 49 (113 km), say 100-130 km.

On a somewhat broader scale, similar argument attaches to the large M_{21} amplitudes of events 23 and 65, having focal depths between 120 and 160 km.

A smaller amplitude ratio of the leading (M_{21}) group, to later groups in event 80 would be expected because of its shallower focal depth. This appears to be so,

3.3 RESULTS

3.3.1 Fundamental Mode

The location of the phase velocity profile in the velocity period plane was established from "two-station" results appropriate for the Gulf of Papua. This was checked against single station profiles

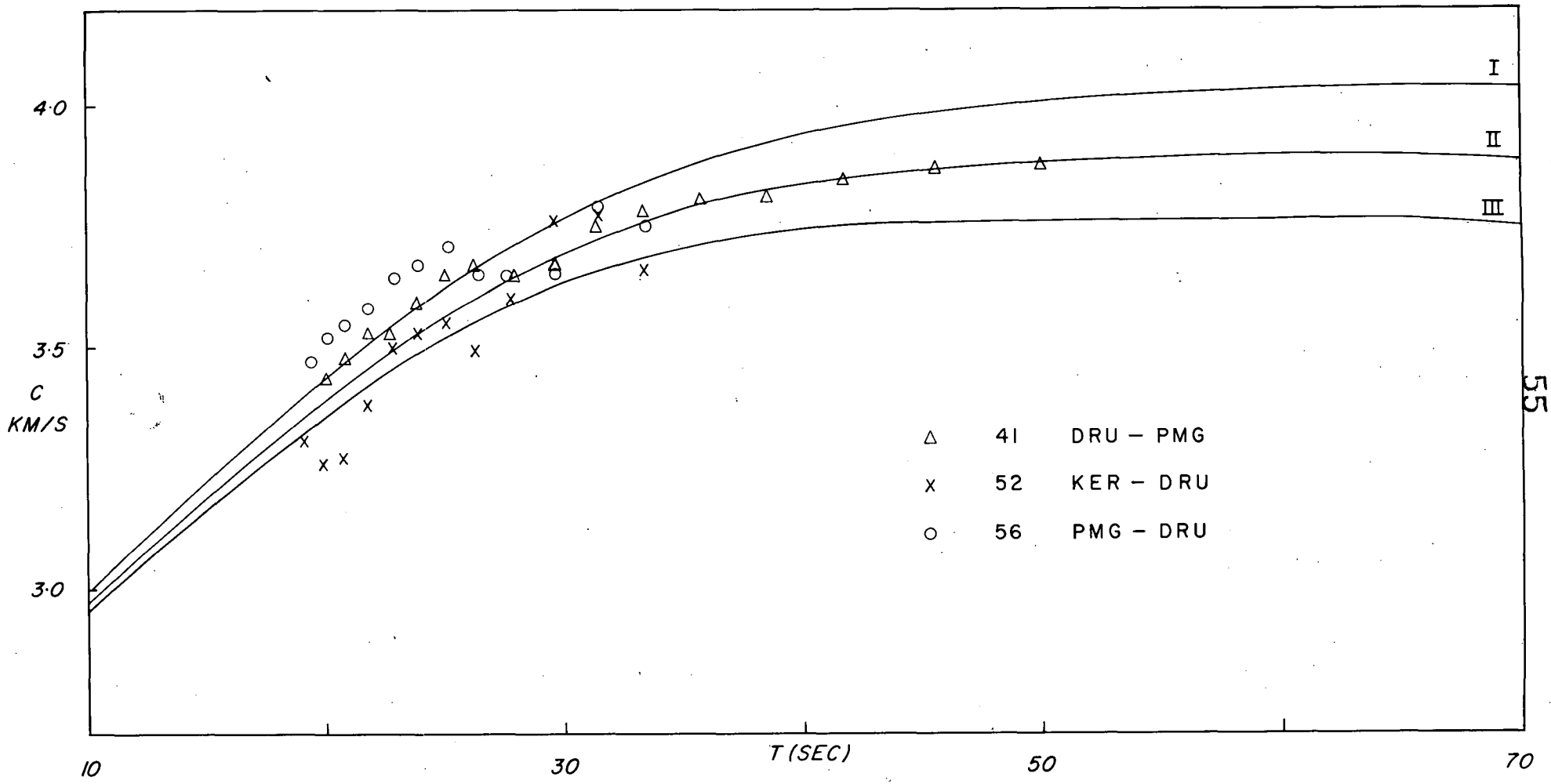

FIG 13 TWO STATION FUNDAMENTAL MODE DISPERSION. PROFILES I, II, III, INDICATE CHANGES PRODUCED BY INCREMENTS OF $\pm\pi/2$ TO THE TRAVEL TIMES, AND ARE POLYNOMIALS FITTED TO DATA IN FIG.15

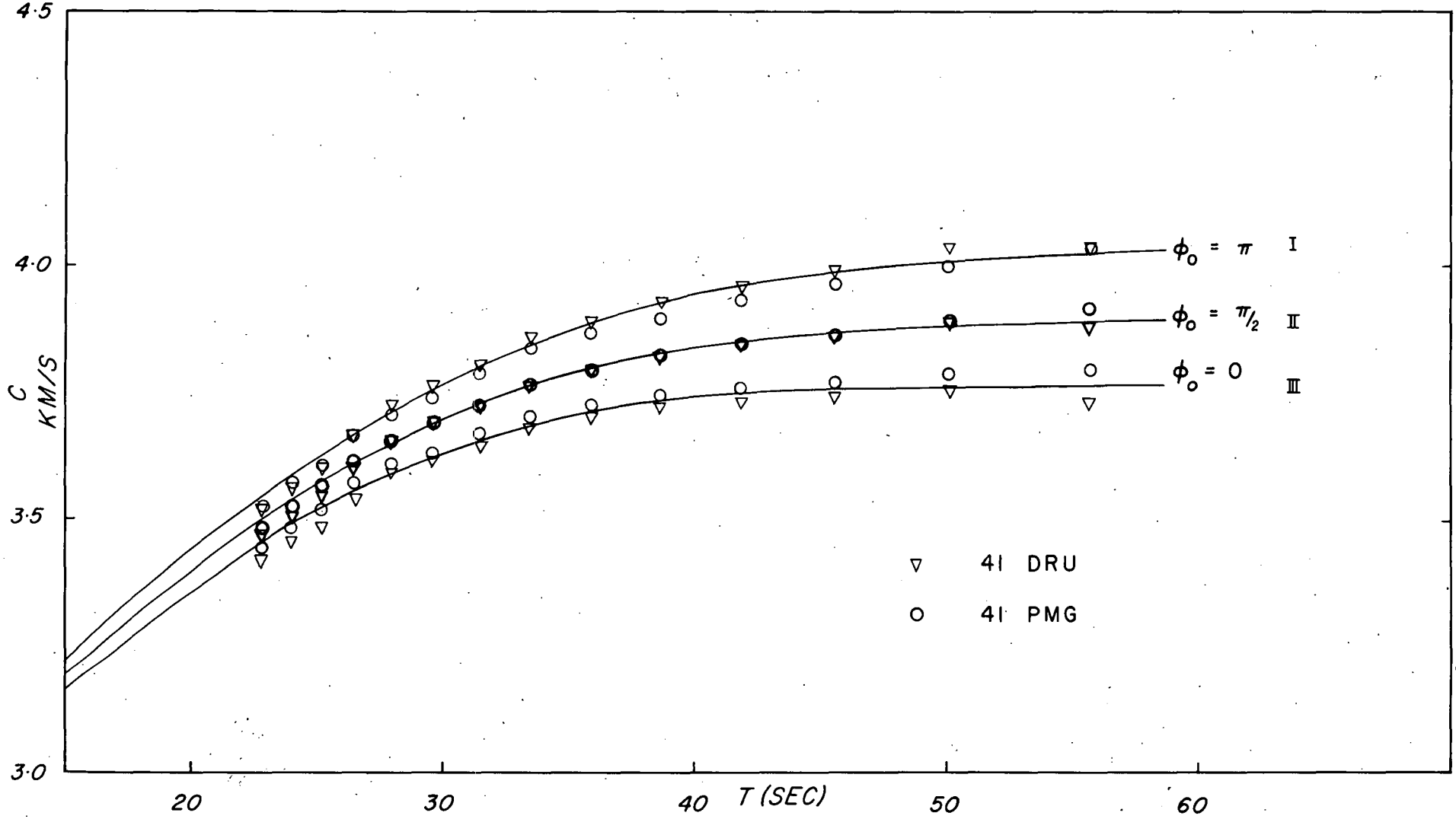

FIG 14 EVENT 41. ALTERNATIVE SETS OF FUNDAMENTAL MODE PHASE VELOCITIES.

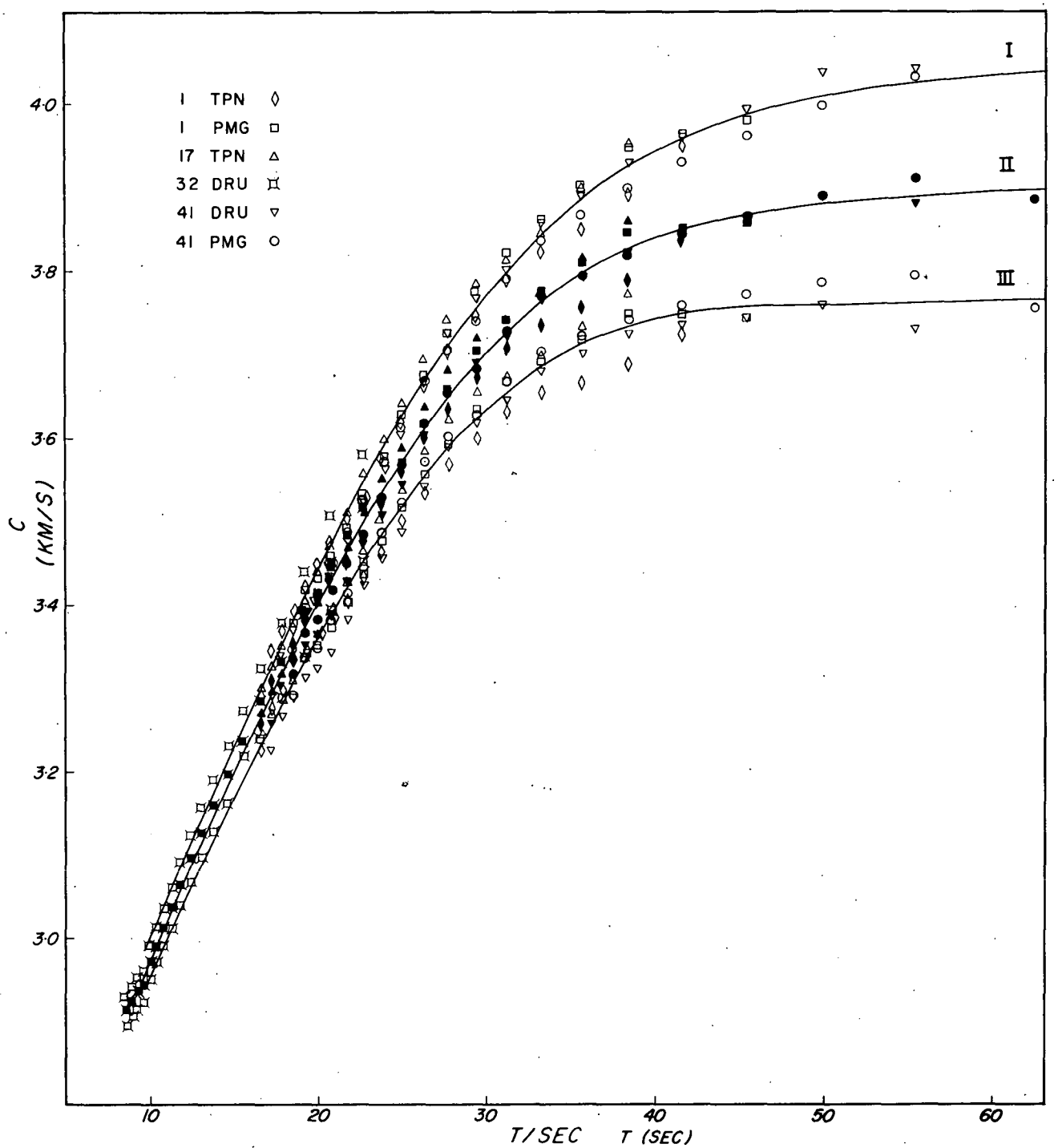

FIG 15 OBSERVED FUNDAMENTAL MODE PHASE VELOCITIES FOR ALL EVENTS. SMOOTHED PROFILES I, II, III, ARE LEAST SQUARE POLYNOMIALS FITTING EACH SET.

recorded at different distances and finally also confirmed by group velocity comparisons.

Fig. 13 shows "two-station" phase velocities determined from events 41, 52, 56. The effects of disturbance caused to the spectra of recordings of 52 and 56 by transmission across the cordillera are clear, and invalidate the velocities measured over such short distances. Only event 41 gives a consistent indication of phase velocity independent of ϕ_o.

Fig. 14 shows three alternative sets of single station velocity profiles surrounding the velocity: period region identified in Fig. 13. These apply to paths including but more extensive than covered by the two station data, the two outer sets of profiles indicates that the ϕ_o controlling the central profile is very nearly correct because it shows maximum agreement between events.

Fig. 15 shows all profiles for the remaining paths employing events, 1, 17, 32 as well as 41, arranged in 3 sets. The separation of profiles for the longest and shortest paths (17TPN, 32DRU respectively) is smallest for the central set.

TABLE 4

Least Square Polynomials, Fundamental Mode

$C = a_o + a_1 t + \ldots\ldots\ldots a_5 t^5$

	I	II	III
a_o	2.6459676	2.6605538	2.6711910
$a_1 \times 10^2$	1.7740255	1.1820261	0.6765646
$a_2 \times 10^3$	2.5723917	2.9336375	3.2311624
$a_3 \times 10^4$	-0.9741765	-1.1178005	-1.2392342
$a_4 \times 10^6$	1.3023602	1.5332697	1.7320007
$a_5 \times 10^9$	-6.1380516	-7.4108461	-8.5181774
R.M.S. Dev. (KM/S)	$\pm$ .018	$\pm$ .016	$\pm$ .018

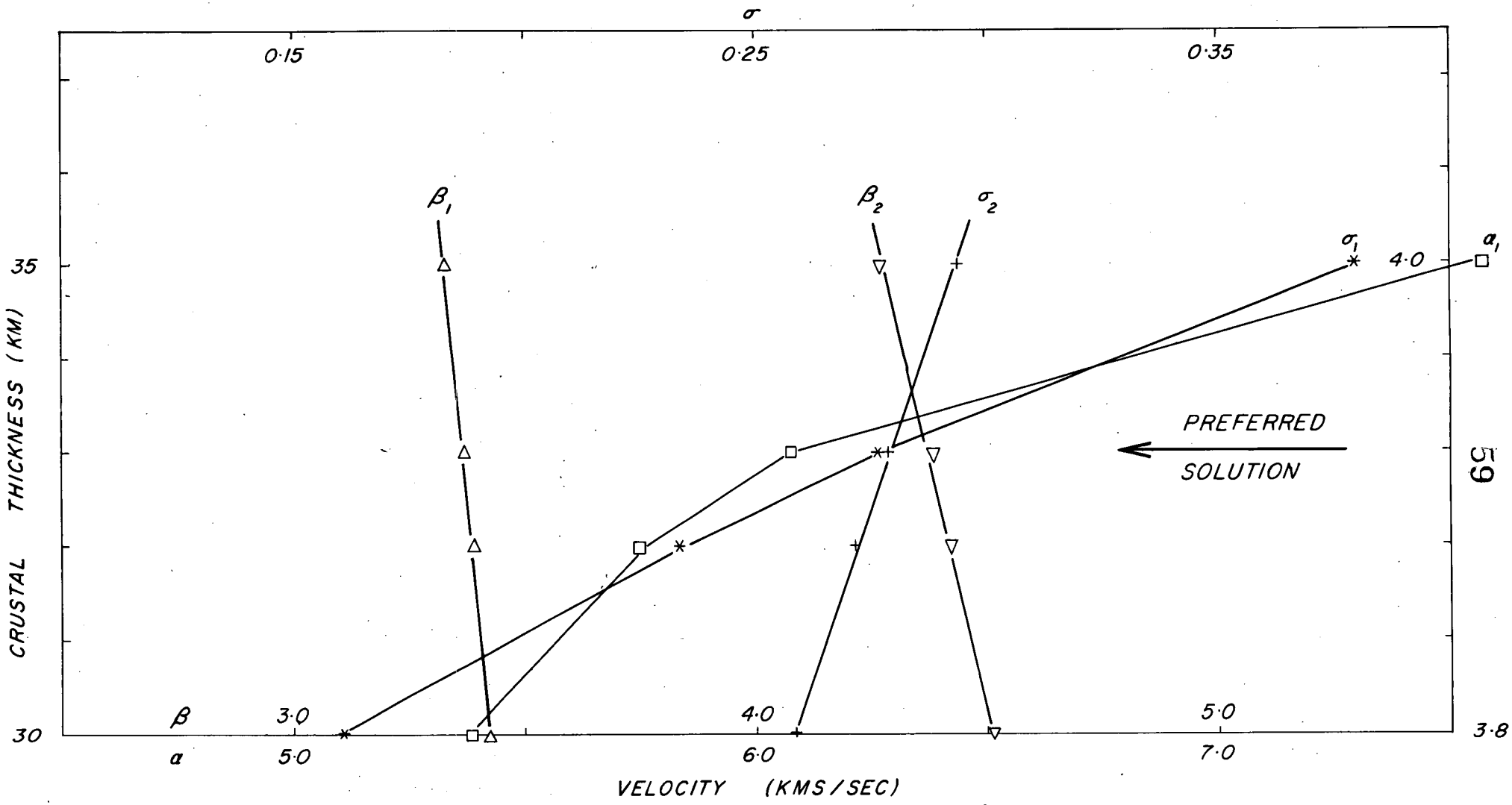

FIG. 16 TWO LAYER MODEL INVERSIONS OF POLYNOMIAL II FOR FIXED CRUSTAL THICKNESSES (h_1), OF 30, 32, 33, 35 KM. SUBSCRIBTS REFER TO MODEL LAYERS REPRESENTING CRUST, (1), AND MANTLE, (2).

The coefficients of polynomials, I, II, III fitted to these data in a least square sense are shown in Table 4 and corresponding profiles superimposed on Figs. 13, 14 and 15. RMS deviations, also in Table 4 compare very favourably with standard errors found by others for several regions of the world (Table 5), and are smallest for polynomial II. This profile is clearly favoured at long periods by the two-station data (Fig. 13).

TABLE 5

Fundamental Mode Rayleigh Wave Phase Velocity Studies

Comparison of Observed Scatter

Region	Period	RMS or Other Deviation km/s	Reference
Japan	20 - 30	± .03 (± 1 to 1.5%)	Aki (1961)
Eastern U.S.A.	16 - 45	± .04	Dorman & Ewing (1962)
Canadian Shield	3 - 90	± .03	Brune & Dorman (1963)
Finland	10 - 60	± .02	Noponen (1966)
European Alps	10 - 80	Not given but ± .05	Knopoff et al (1966) - Fig. 12
Mediterranean	30 - 100	± .03 (assumed)	Berry & Knopoff (1967)
Southern New Guinea	8 - 70	± .02	

The phase velocities defined by polynomials I and II were inverted to find parameters of a two layered model by employing the σ criterion explained earlier. Several solutions which match profile II are shown in Fig. 16. These solutions include crustal layers of different thickness, with the preferred solution chosen according to the value of σ for the crust. Model parameters for preferred solutions for both profiles are given in Table

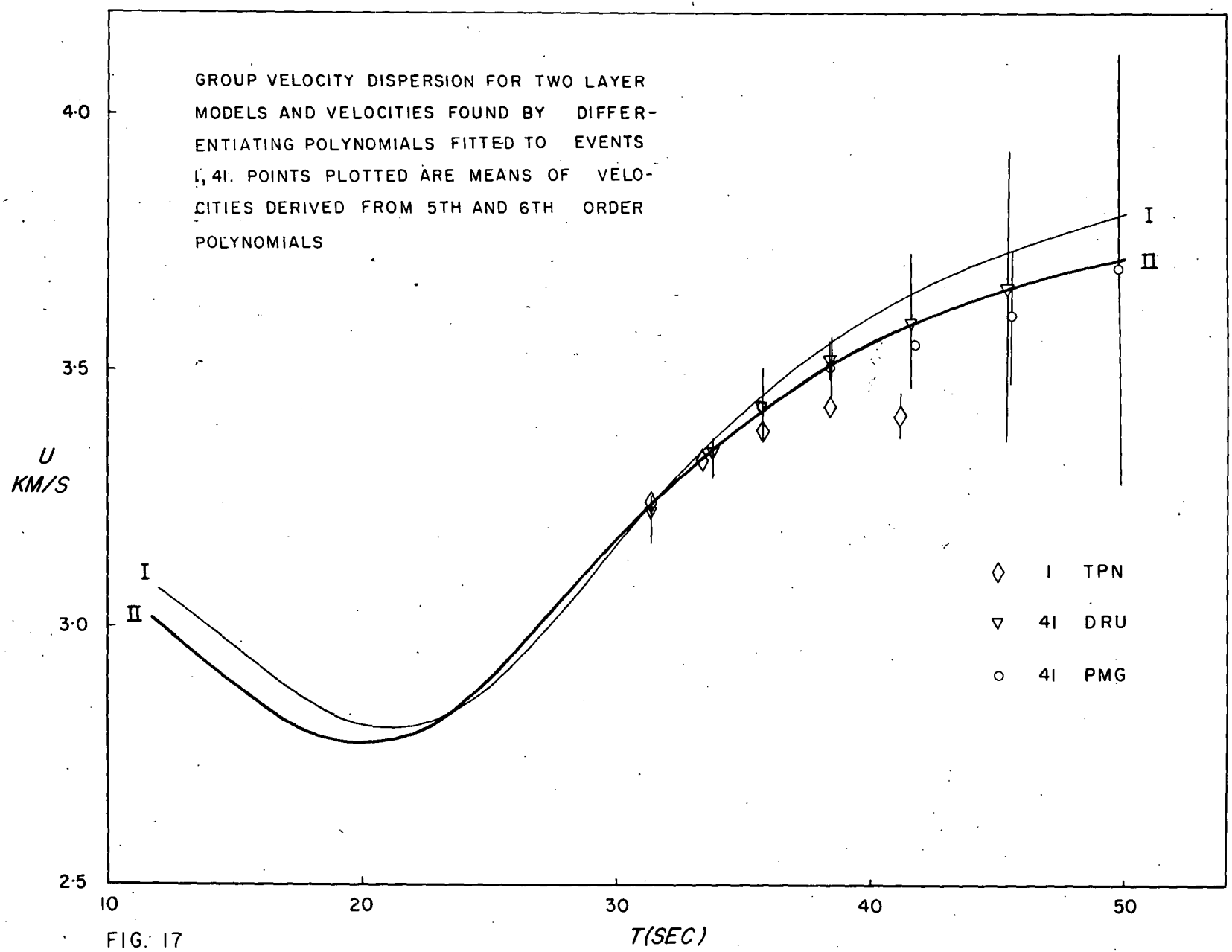
GROUP VELOCITY DISPERSION FOR TWO LAYER MODELS AND VELOCITIES FOUND BY DIFFERENTIATING POLYNOMIALS FITTED TO EVENTS 1, 41. POINTS PLOTTED ARE MEANS OF VELOCITIES DERIVED FROM 5TH AND 6TH ORDER POLYNOMIALS
4·0
3·5
3·0
2·5
U KM/S
10
20
30
40
50
T(SEC)
I
II
I
II
◇ 1 TPN
▽ 41 DRU
○ 41 PMG

FIG. 17

6. Fig. 16 shows the expected change of about .07 in σ_1 due to a 2 km change in h_1. The preferred value of h_1 = 33 km ± 1 km is consistent with a range in σ_1 of 0.23 to about 0.32.

TABLE 6

Alternative Two Layer Models

C(T) Polynomial	Layer	Parameters			
		h (km)	α (km/s)	β (km/s)	ρ (gr/cc)
I	Crust	35.0	6.13	3.45	2.80
	Mantle		8.00	4.55	3.32
II (Preferred Solution)	Crust	33.0	6.08	3.38	2.80
	Mantle		7.90	4.38	3.32

Phase velocities for the centre profile group and corresponding values of ϕ_0 are listed in Table 7.

The group velocities for both models are shown in Fig. 17, and compared with the results of differentiating polynomials fitted to events 1 TPN, 41 PMG, 41 DRU which gave the smoothest phase velocities covering the longest periods.

Polynomials of 5th and 6th order were fitted and average group velocities are shown. These favour the model from polynomial II. As expected, the difference between the two sets of results at long periods is much greater than for the synthetic data of Appendix III but the averages favour polynomial II and support the conclusions drawn from Figs, 13 and 14 that polynomial II defines the correct phase velocity profile.

It is worth noting that use of group velocities to discriminate between models is restricted almost entirely to waves of periods exceeding 30 sec.

TABLE 7

Observed Phase Velocities and Initial Phase

Fundamental Mode

T	C (PATH) - KM/SEC						POLYNOMIAL II	
(SEC)	1TPN	1PMG	17TPN	32DRU	41DRU	41PMG	T	C
71.43						3.871	70.0	3.881
62.50						3.885	62.0	3.897
55.56					3.880	3.911	56.0	3.890
50.00					3.893	3.889	50.0	3.880
45.45		3.856			3.865	3.866	46.0	3.870
41.67	3.835	3.851			3.845	3.844	42.0	3.853
38.46	3.786	3.845	3.861		3.824	3.819	40.0	3.840
35.71	3.756	3.808	3.814		3.793	3.795	38.0	3.822
33.33	3.737	3.775	3.770		3.766	3.769	36.0	3.800
31.25	3.709	3.743	3.743		3.722	3.728	34.0	3.773
29.41	3.671	3.703	3.720		3.692	3.684	32.0	3.739
27.78	3.634	3.658	3.682		3.657	3.654	30.0	3.699
26.32	3.598	3.615	3.638		3.603	3.619	28.0	3.653
25.00	3.560	3.572	3.589		3.544	3.568	26.0	3.599
23.81	3.578	3.526	3.550		3.510	3.529	24.0	3.538
22.73	3.481	3.485	3.510	3.516	3.474	3.485	22.0	3.471
21.74	3.453	3.447	3.469		3.427	3.450	20.0	3.398
20.83	3.430	3.415	3.432	3.452	3.387	3.418	18.0	3.319
20.00	3.406	3.391	3.401		3.363	3.381	16.0	3.236
19.23	3.381	3.378	3.369	3.389	3.352	3.368	14.0	3.149
18.52	3.354		3.340		3.331	3.318	12.0	3.062
17.86	3.333		3.317	3.333	3.304		10.0	2.975
16.67	3.258		3.270	3.283				
15.62				3.236				
14.71				3.196				
13.89				3.159				
12.50				3.095				
11.36				3.037				
10.42				2.992				
9.26				2.935				
8.62				2.913				
ϕ_o	$-\frac{\pi}{2}$	$-\frac{\pi}{2}$	$+\frac{\pi}{2}$	$-\frac{\pi}{2}$	$+\frac{\pi}{2}$	$+\frac{\pi}{2}$		

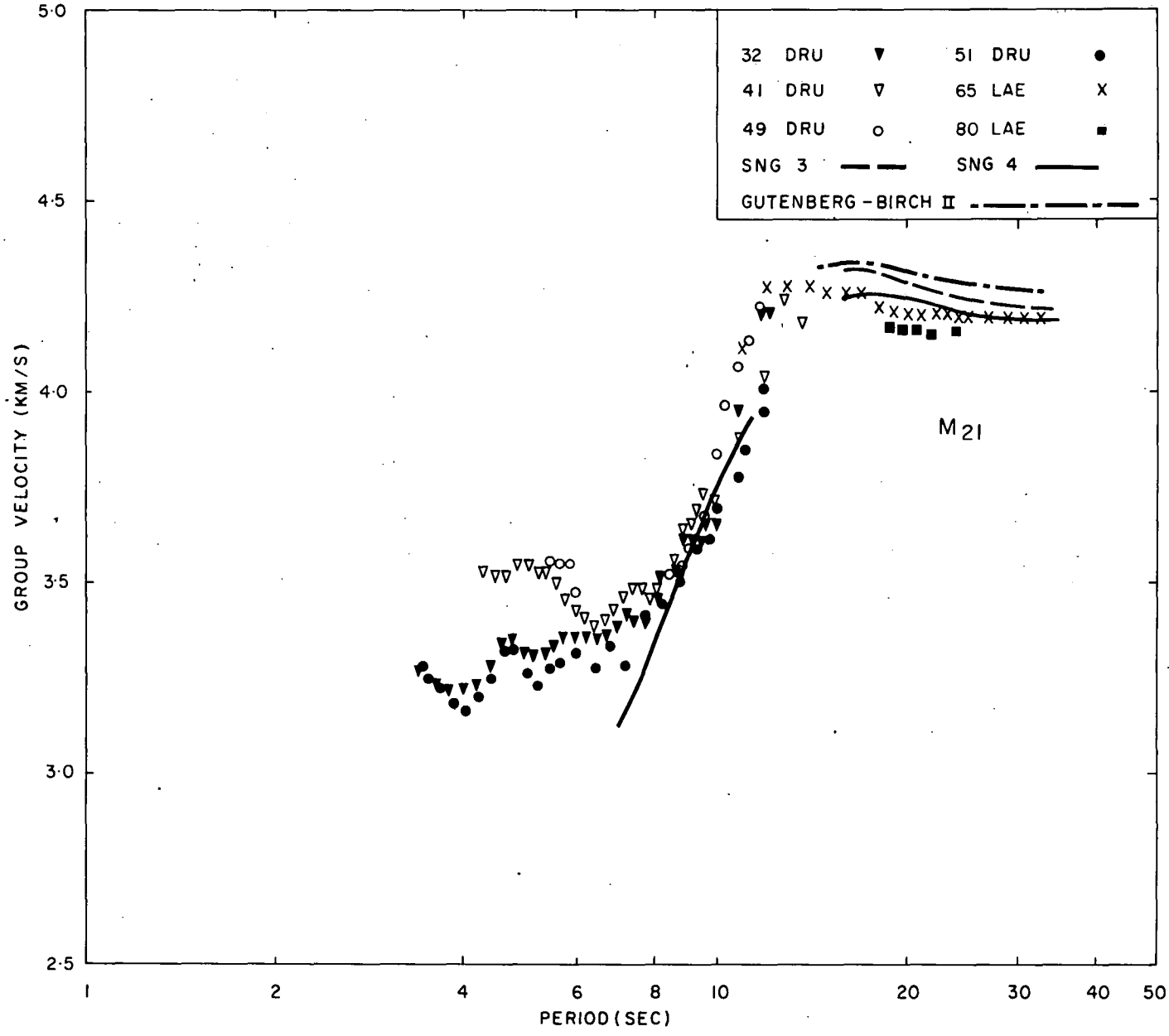

FIG. 18 COMPARISON OF M_{21} GROUP VELOCITIES WITH SNG 3, SNG 4 AND GB MODEL VELOCITIES

3.3.2 First Higher Mode

(i) Group velocities

The group velocities shown in Fig. 18 were determined using the filtering technique explained in Appendix III (b).

The velocity gradient between 6 and 12 seconds, and the velocity maximum between 13 and 15 seconds can both be associated visually with the seismograms of Figs. 11 and 12. For periods longer than 10 seconds a general correspondence in shape with dispersion for the Gutenberg model (Kovach and Anderson, 1964) indicates the presence of a low velocity zone in the upper mantle.

At periods below about 6.5 seconds, dispersion of events 32 and 51 differs significantly from 41 and 49. These periods are most sensitive to upper crustal structure. Moreover, Fourier phase spectra for the former two events are smoother, and corresponding group velocities may therefore better represent the shallow structure of the region which controls dispersion in this period range. A much greater proportion of the paths of 41 and 49 to Daru extends beyond the 2000 m bathymetric contour (Fig. 10) than for either 32 or 51 and heterogeneity in shallow structure along the path might therefore exist.

The presence of maxima and minima in a group velocity dispersion curve has been shown by Alexander (1963) to indicate that significant velocity "layering" exists within the depth interval controlling the dispersion in question. This correlation is more obvious for the fundamental mode, having a simple displacement profile, than for higher modes with multilobed displacement profiles, but is displayed by the M_{21} mode for constant velocity crustal segments of 19 km thickness e.g. Kovach and Anderson (1964). The existence of layers of these dimensions within the southern New Guinea crustal velocity profile should therefore be evident from the shape of the observed profile (Fig. 18). Accordingly steadily increasing group velocities

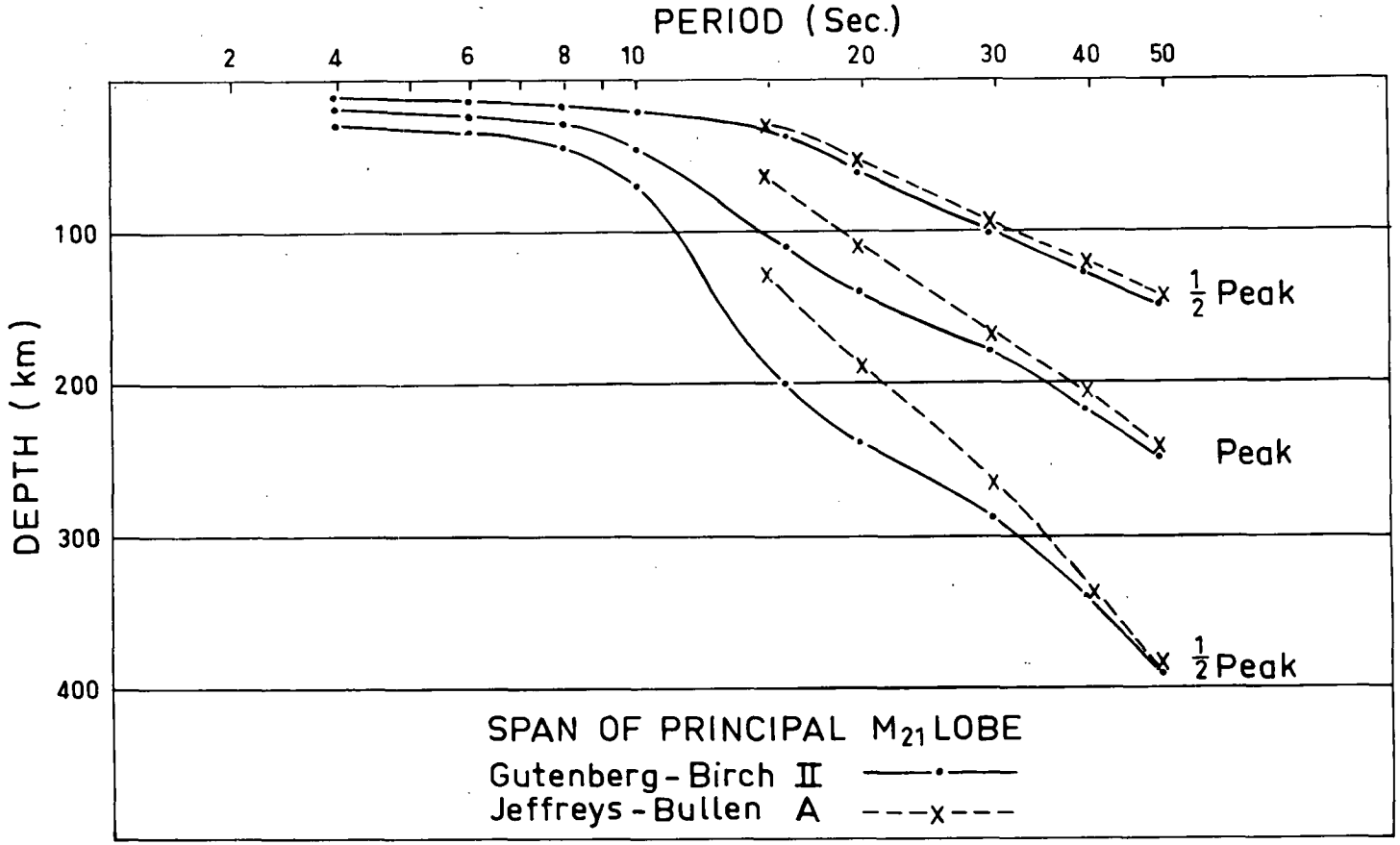

FIG. 19 APPROXIMATE SPAN OF PRINCIPAL LOBE OF VERTICAL DISPLACEMENT PROFILE FOR MODE M_{21}.

between 9 and 12 seconds (Fig. 18) are taken to indicate absence of pronounced layering and thus presumably smoothly varying velocity structure from the M discontinuity to depths probably between 50 and 100 km (Fig. 19).

Fig. 19 is intended to portray the general penetration characteristics of M_{21} by indicating, for both Gutenberg and Jeffreys velocity models, the depth of the dominant lobe of vertical displacement by the depth of its maximum and half maximum amplitudes as a function of period. Although the group velocity for a given period is a function of the whole shear velocity profile, it is more sensitive to shear velocities in regions where displacements are large. In Fig. 19 attention is confined to vertical displacements of M_{21} which are significantly greater than horizontal displacements (Kovach and Anderson, 1964).

These displacement data were computed using a dispersion program, PV7 (Dorman, 1962). This was modified to extract displacements at layer boundaries, after rewriting it in Algol for use on the Elliott 503 computer (8K store) at the University of Tasmania. Shear and compressional velocities were modified in accordance with the "earth-flattening" formulae of Alterman et al (1961).

Below 100 km, the existence of a low shear velocity channel is indicated by group velocity maxima at 13-15 seconds, not predicted by the Jeffreys-Bullen model. This peak is fairly sharp and implies that the high velocity "cap" is not extensive in depth. The broad minimum following the peak (not terminated by these data) indicates that the lower boundary of the low velocity region is below 200 km.

We can expect the shear velocities capping this zone to correspond approximately with the phase velocities at these periods (Kovach and Anderson, 1964). These are probably close to those of the Gutenberg model (i.e. = 4.5 km/sec.) the dispersion curve for which lies just above the plotted points near 15 seconds period (Fig. 18).

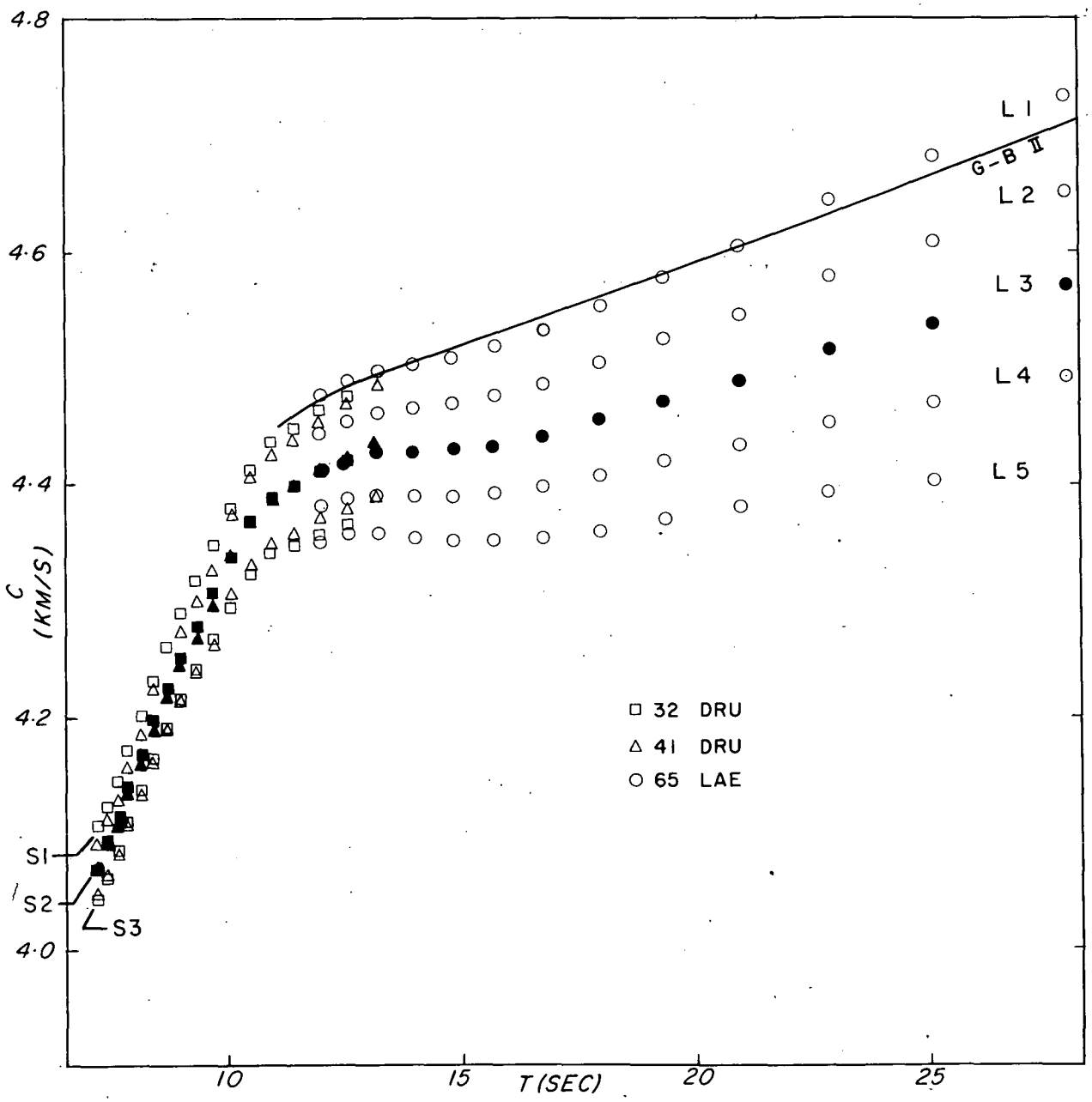

FIG. 20 OBSERVED AND G B MODEL M_{21} PHASE VELOCITIES. SHORT PERIOD SEGMENTS ARE LABELLED S1, S2, S3 AND LONG PERIOD SEGMENTS L 1 THROUGH L 5.

Scatter in the plotted group velocities between 10 and 15 seconds may be caused partly by mode superposition or by refraction effects. Because the penetration of the M_{21} mode is substantial, one might expect reflection and refraction effects in a region of crustal thickening to be less pronounced than for the fundamental (M_{11}).

(ii) Phase velocities

There are no 'two-station' results in this case.

Phase velocity profiles for several values of ϕ_o are plotted in Fig. 20 for events 32, 41 at the short period (S) end, and 65 at the long period (L) end of the spectrum. The S profiles for increments of $\phi_o = n\pi/2$ are more widely separated than the L profiles because epicentral distances of events 32 and 41 were 500 to 800 km less than event 65.

Observed M_{21} group velocities and M_{11} phase velocities are both consistently less than corresponding theoretical data for the Gutenberg-Birch II (GB) model (Figs. 18, 21). This suggests that the GB model shear velocities represent an upper limit to the possible range of velocities beneath southern New Guinea. Thus profile L1, close to the GB dispersion for mode M_{21} (Fig. 20) represents an upper limit for the choice of the correct profile.

Continuity of profiles S2-L3 is slightly but not clearly better than S3-L4. RMS deviations of least square 5th order polynomials through both sets are about equal and less than other profiles.

Profiles L2 through L5 were inverted in terms of a 5 layer model structure for three sets of conditions viz. floating all five or the lower or upper four shear velocities. In all cases the starting values were 4.5 km/sec. for layers below the Moho and 3.4 km/sec. above. Results were rejected if any parameter failed to stabilise or if RMS deviations failed to decrease or hold low values.

Densities for these models are those of Bullen and Haddon (1967). Compressional velocities approximate the Gutenberg profile. Both remained

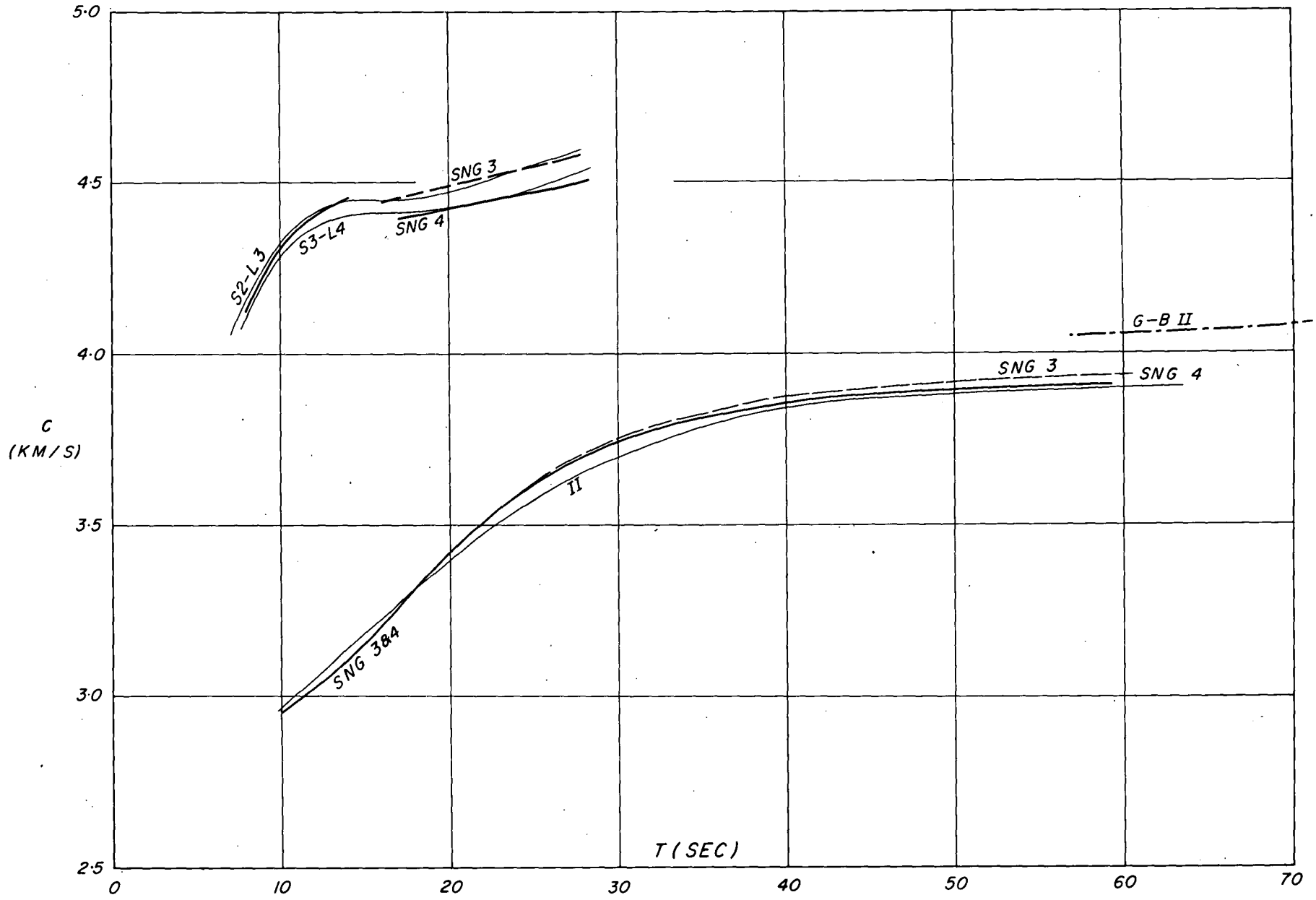

FIG. 21 - COMPARISON OF GB, SNG 3 AND SNG 4 PHASE VELOCITIES WITH OBSERVED FUNDAMENTAL MODE PROFILE II AND HIGHER MODE PROFILES S2—L3 AND S3—L4.

fixed throughout the problem. The layering structure adopted was a modified version of that used by Harkrider et al (1963) to represent the Gutenberg upper mantle velocity profile. These thicknesses also remained fixed.

Profile L5 failed to invert to a stable model under any of the three conditions and this was interpreted to indicate that it is a physically implausible profile. The results of remaining inversions were examined in two ways:

(1) Layer 2 velocities were compared with the sub-Moho velocity of about 4.4 km/sec. determined from fundamental mode data.

(2) Group velocities of the models were compared with the observed data shown in Fig. 18.

TABLE 8

Inversion of long period segments of M_{21} phase velocities

Layer	h	α	ρ	β (km/sec.)					
	km	km/sec.	gr/cc	L2		L3		L4	
1	35	6.1	2.8	*3.40		3.53		*3.40	
2	40	7.9	3.2	4.90	**4.52	4.51	4.46	4.61	4.43
3	50	7.8	3.4	4.15		4.40		4.27	
4	75	7.8	3.4	4.41		4.22		4.22	
5		8.0	3.6	4.53		*4.50		4.37	
RMS deviation (km/s)				±.007		±.007		±.006	

* Fixed parameter ** Average of layer 2 and 3 velocities

The three best solutions, being the only ones having RMS deviations less than ± 0.01 km/sec., are given in Table 8. Model L2 is inconsistent with the sub-Moho velocity of 4.4 km/sec. derived from the fundamental mode data (Table 6), and group velocities for this model (not

shown) are also higher at both short and long periods than the observations in Fig. 18.

No distinguishing characteristics were found to suggest which of the remaining profiles, L3 or L4 was more nearly correct. The difference between the two profile sets S2-L3 and S3-L4, at periods near 10 to 15 seconds, is less than the discrepency expected from a source directed at 45° to the vertical, as discussed in Appendix I (b). The region spanned by the two profiles therefore represents the best definition of M_{21} phase velocity dispersion available for the waveguide in the circumstances.

3.4 INTERPRETATION

3.4.1 Choice of Parameters

(i) Compressional Velocities

The existence of a low shear velocity zone is clear from the M_{21} group velocities. Sensitivities of C to α values at all depths below the Moho are very low, and so the profile reported by Brooks (1962) was adopted and modified where necessary to ensure a value of $\sigma \gtrsim .25$ in each layer.

(ii) Densities

Because sensitivity of phase velocity to density (particularly below the Moho) is low, an average upper mantle profile was employed. (Chapter 2) Some models were re-run to test the shear velocity solution against alternative distributions, without significant change in the shear velocities.

(iii) Thicknesses

A crustal thickness of 33 km (Moho depth) was first established using the "σ criterion" discussed above.

The subdivisions within the crust were then adopted after

TABLE 9

Observed Phase Velocities and Initial Phase

Model M_{21} - Profile S3-L4

PERIOD	C (PATH) - KM/SEC				
Sec.	32DRU	41DRU	51DRU	65LAE	80LAE
27.78				4.495	
25.00				4.470	4.492
22.73				4.455	4.461
20.83				4.435	4.428
19.23				4.422	4.406
17.86				4.410	4.391
16.67				4.400	4.388
15.62				4.395	
14.71				4.393	
13.89				4.394	
13.16		4.390		4.395	
12.50	4.368	4.380		4.392	
11.90	4.362	4.371		4.385	
11.36	4.350	4.358			
10.87	4.345	4.348	4.321		
10.42	4.325	4.332	4.300		
10.00	4.298	4.305	4.266		
9.26	4.244	4.237	4.214		
8.62	4.194	4.189	4.177		
8.06	4.140	4.133	4.110		
7.58	4.090	4.081	4.063		
7.14	4.046	4.048	4.011		
ϕ_o	0	$-\pi/2$	$+\pi$	$-\pi/2$	0

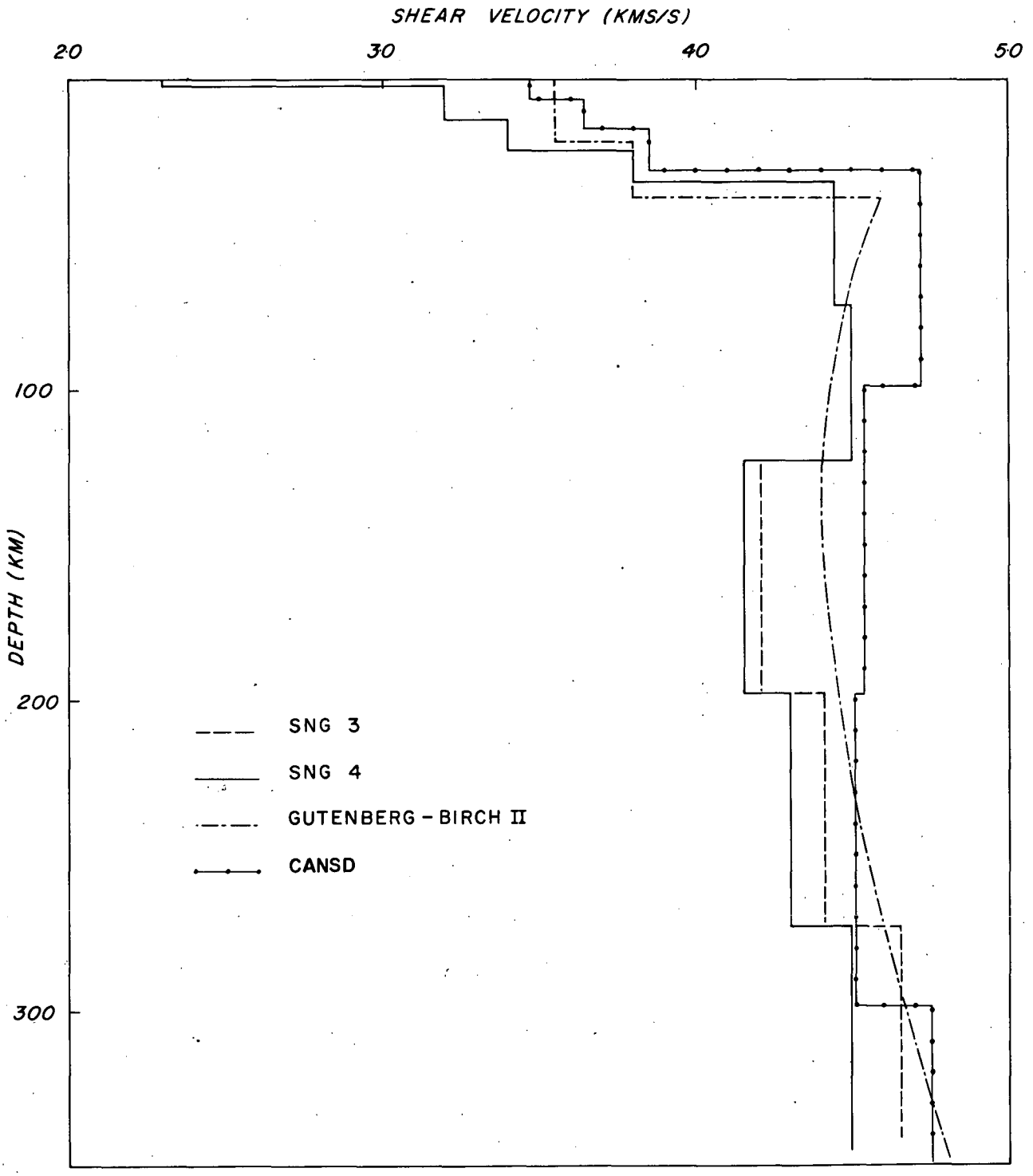

FIG 22 COMPARISON OF SNG 3 AND SNG4 SHEAR VELOCITY PROFILES WITH OTHERS

incorporating the superficial layer specified in section 3.1. Division of the remaining 31 km of crust into 3 layers (arbitrarily assigned equal thicknesses) produced a better agreement with the short period M_{21} group velocities than occurs with only one or two layers.

A nominal mantle layering was adopted, being a modified version of that used by Harkrider et al (1963) to represent the Gutenberg model of the upper mantle. Variations of it were tested without finding a clearly superior layering structure. The southern New Guinea upper mantle seems to conform, generally, with this form of profile.

3.4.2 Inversion of Shear Velocities

Combined fundamental mode data (polynomial II) and higher mode data for S2-L3 were jointly inverted to produce model SNG3. Group and phase velocities are displayed in Figs. 18 and 21.

Employing partial derivaties, SNG3 was modified to fit L4, and the resulting structure designated SNG4. Phase velocities for profile S3-L4 are listed in Table 9. The shear velocity profiles matching both dispersion curves S2-L3 and S3-L4 are plotted in Fig. 22 and both models listed in Table 10.

Some typical partial derivative profiles $\partial c/\partial \beta$ and $\partial c/\partial h$ for both modes are shown in Figs. 23 and 24. These relate to model SNG4.

Model phase and group velocity profiles are shown in segments corresponding to models with lower boundaries at 125 and 275 km. The inversion program employed could not accurately compute phase velocities at short periods for deep structures because loss of significant figures occurred in the calculation of the characteristic determinant using the Haskell matrix method. The computational problem has been discussed by Rosenbaum (1964) but these modifications were not incorporated in the program used for this investigation.

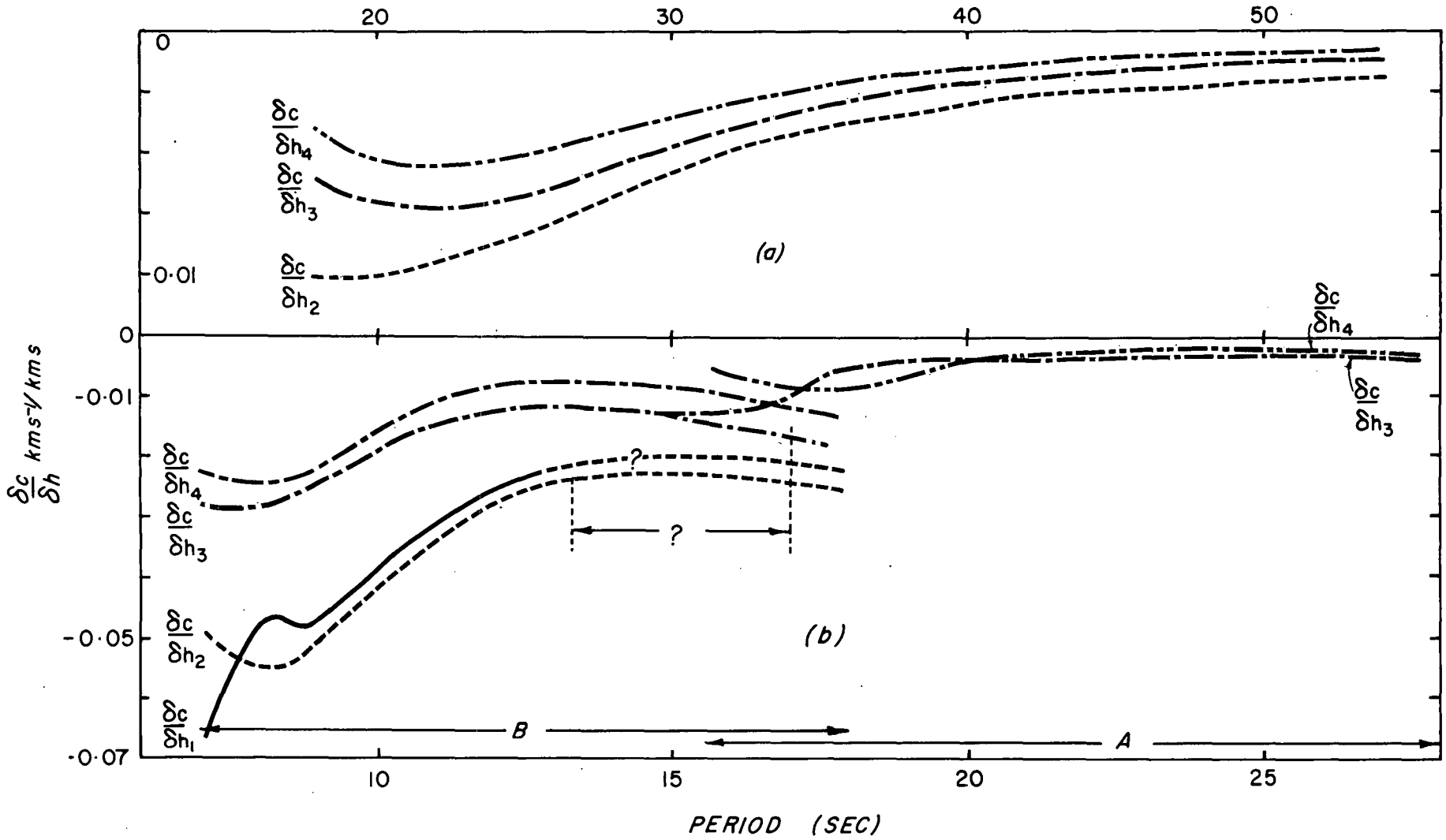

FIG. 23 PHASE VELOCITY SENSITIVITY TO LAYER THICKNESSES, MODEL SNG 4
(a) FUNDAMENTAL MODE. SENSITIVITIES TO LAYERS 5-9 ARE BELOW 0·01 km s^{-1}/kms
(b) MODE M_{21}. SENSITIVITIES TO LAYERS 5-9 ARE BELOW 0·01 kms^{-1}/kms
PROFILES *(A)* COMPUTED FROM COMPLETE MODEL. PROFILES *(B)* FROM MODEL TRUNCATED AT LAYER 6 (125km).

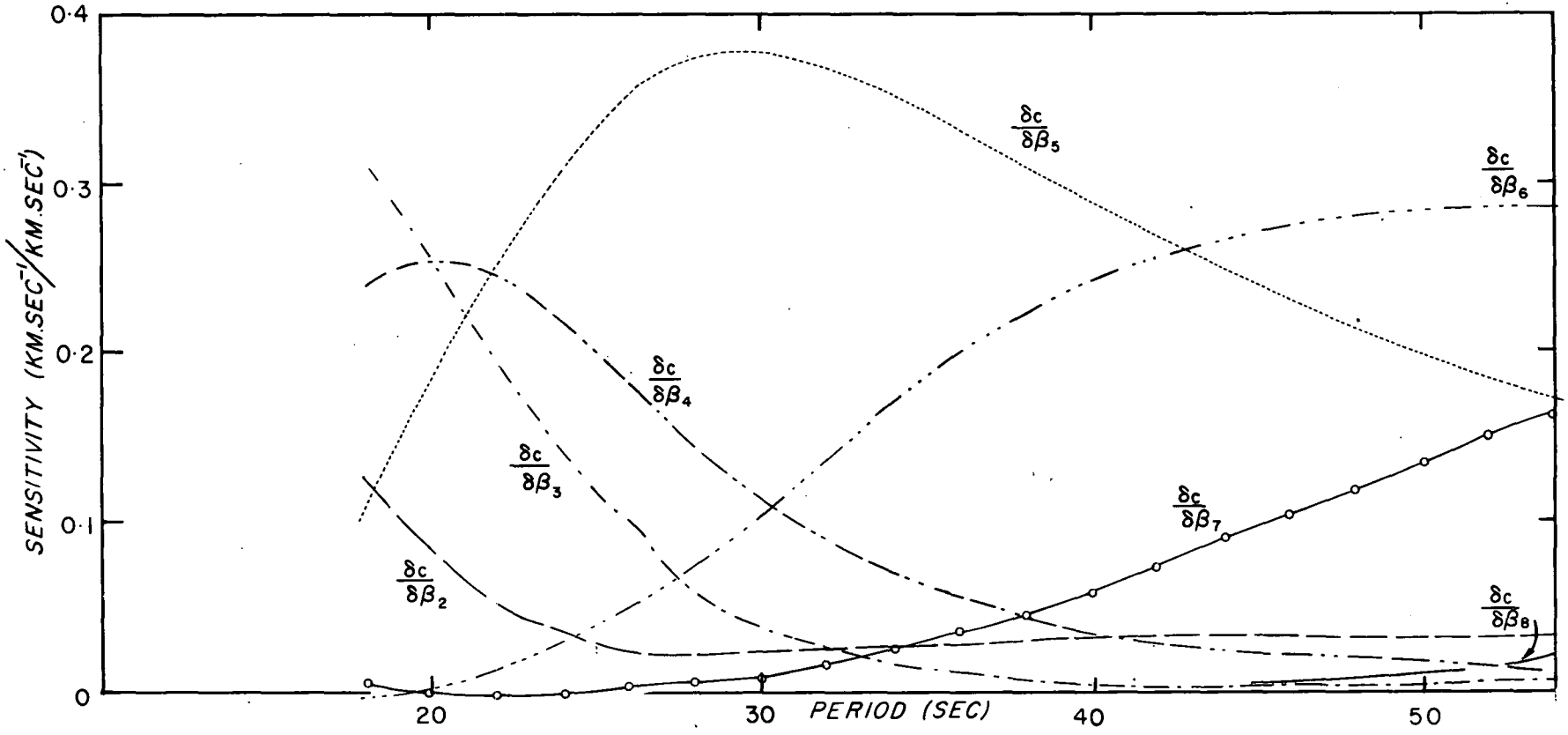

FIG 24.(A) PHASE VELOCITY SENSITIVITY TO SHEAR VELOCITY, MODEL SNG4, FUNDAMENTAL MODE.

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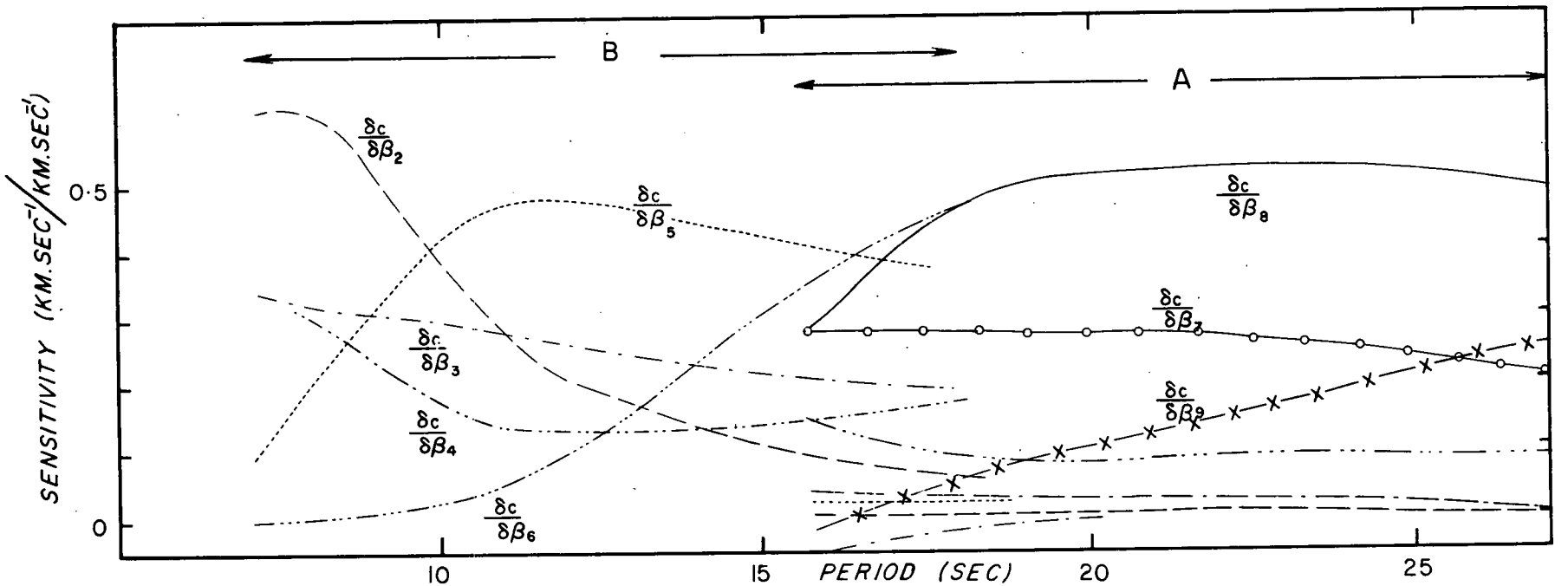

FIG 24 (B) PHASE VELOCITY SENSITIVITY TO SHEAR VELOCITY, MODEL SNG 4
MODE M_{21} PROFILES (A) FROM COMPLETE MODEL
PROFILES (B) FROM TRUNCATED MODEL

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TABLE 10

Models SNG3 and SNG4

Depth (km)	Layer Thickness (km)	Compr. Veloc. (km/s.)	Shear Veloc. (km/s.) SNG3	SNG4	Poissons Ratio SNG3	SNG4	Density (gr/cc)
2	2	4.0	2.30		.253		2.3
13	11	5.6	3.20		.258		2.75
23	10	5.9	3.40		.251		2.8
33	10	6.6	3.80		.252		2.9
73	40	7.9	4.44		.269		3.32
123	50	7.85	4.50	4.45	.255	.263	3.34
198	75	7.50	4.20	4.15	.272	.279	3.34
273	75	8.0	4.40	4.30	.283	.297	3.36
		8.1	4.65	4.50	.254	.277	3.36

The discontinuities evident in the layering structure, apart from the M-discontinuity were not precisely determined. Several test inversions floating crust and mantle layer thicknesses as well as shear velocities were run. Thickness sensitivities are too low to float these exclusively. The average profile already defined is not significantly different from other variations of it. It is thought that the negative shear velocity gradient is probably steepest at around 100-125 km depth.

The combination of modes exercises a strong constraint on the general form of the model. For example, while a thinner lid above the low velocity zone would be tolerated by the fundamental mode data alone, a reduction of, say 500 km in $h_5 + h_6$ and a corresponding increase in h_7 would perturb the higher mode velocities in the period range 10-15 seconds by perhaps 0.1 km/sec.

Departures of more than about $\pm$ 0.1 km/sec. in the crustal shear velocity profile cause significant changes in the short period M_{21} phase

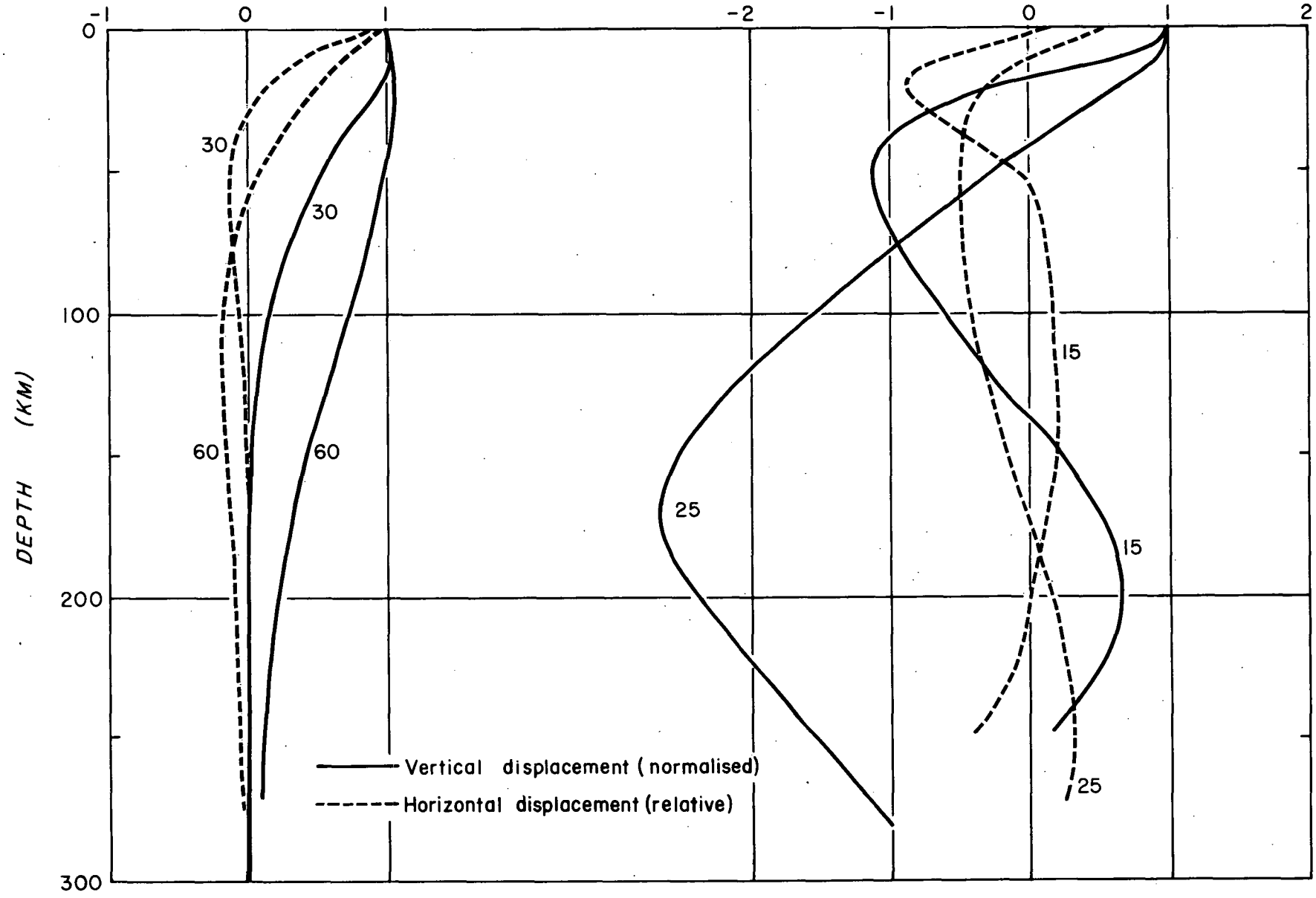

FIG. 25 DISPLACEMENT PROFILE FOR MODEL SNG 4, LABELLED WITH PERIOD (SEC)

velocities, while not influencing M_{11} (for the periods observed) quite so strongly.

SNG4 long period fundamental velocities cannot be reduced by lowering β_5 or β_6 without also lowering the higher mode velocities by greater amounts for some periods.

Model SNG4 is in better agreement with M_{21} group velocities and M_{11} phase velocities than SNG3 from which it differs in the shear velocity of the lower four layers, and is regarded as a more acceptable model although SNG3 velocities may perhaps represent an upper limit.

Some displacement profiles for model SNG4 are shown in Fig. 25.

3.5 DISCUSSION

Better correspondence between SNG4 phase velocity profiles and observed data (Fig. 21) would be difficult to achieve without more data, and attempts to refine the model further are not warranted at this stage of knowledge of the region. The necessity to split the model for short and long period reductions has introduced a slight uncertainty about the fit in the 10 to 15 second period interval for the higher mode. While not crucial, reduction in terms of a continuous spectrum would add confidence to the result.

The range of shear velocities defined by SNG3 and 4 is compared with the GB profile and the CANSD model of Brune and Dorman (1963) in Fig. 22. CANSD velocities are consistently higher than SNG velocities. Increased model velocities to correspond better with CANSD in the depth range 33 to 170 km of SNG4 cannot be justified.

A rough shear velocity profile for the New Guinea - Solomon Islands region was determined by Brooks (1962). Although control was poor, it is nevertheless, interesting to note that the minimum velocity, 4.2 km/sec., and its depth, are quite consistent with the range of shear velocities

defined by models SNG3 and SNG4.

The similar form of the shear velocity profiles SNG4 and CAMSD, viz. both having a 'lid' of about 100 km thickness above the low velocity zone supports the geological evidence, reviewed earlier, which implied that southern New Guinea was a predominantly shield region.

The difference between CAMSD and SNG4 below the Moho is about 0.3 km/sec. Assuming a value for $(\partial\beta/\partial T)_p$ of about -.003 km/sec.$^{\circ}$C listed by Anderson et al (1968) for olivine, a temperature difference of the order of 1000°C is required to account for the discrepancy.

Significant differences in the upper mantle mineralogy of the two regions may be a more plausible conclusion.

The initial phase for events 32 and 41 differ for each mode. It was suggested in section 2.3.3 that an explicit relationship between ϕ_o, mode number and azimuth is not available for the general case, since the particle displacements concerned, depend on structure, mode number, the type of source and its depth. The displacement data from which Fig. 25 was plotted, do provide part of the required information for further studies of the question.

No attempts have been made to extend the method used to fix Moho depth, to determine other interface depths in complex models such as SNG4. This would lead to a lengthy exercise and confidence in the results would depend on the existence of similar profiles for h and α sensitivity at all depths. Greater uncertainty in the low velocity zone than for the crust adds to the difficulties.

Among the more general uncertainties, the possible influence of anisotropy has not been investigated. A minor inconsistency in the fits displayed in Figs. 18 and 21 is displayed by the observed fundamental mode phase velocities which are too low for SNG4 at around 20 to 30 seconds. This is removed if a single layer crust is adopted, a procedure which

produces a worse comparison of higher mode group velocities at periods less than 9 sec. These parts of the spectrum are sensitive to the crustal structure in different ways and the basic conflict may be a function of shear velocity anistropy in the east-west and vertical component shear velocities.

4. THE SOLOMON SEA

4.1 GEOLOGY AND TECTONICS

The Solomon Sea (Fig. 26), described by Carey (1958) as a "spheno-chasm", is a trapezoidal shaped oceanic basin about 4 km deep. It is bounded to the north and west by New Britain and southern New Ireland and to the east and south by the Solomon Islands chain. The Planet Deep, in places more than 8 km deep, is a pronounced tectonic feature providing an inner continuous margin to the basin on the western, northern and eastern sides.

The northernmost elements of the Upper Tertiary Vogel Basin form a southern boundary, together with the Papuan Ultramafic Belt which extends along the north Papuan coast from Morobe, 400 miles east south east through the D'Entrecasteaux, Bonvouloir and Misima Islands.

This is a large body of peridotite and gabbro which Davies (1968) believes originated as mantle material,"moved westward in late Cretaceous or early Tertiary time and" ... rode ... "up over the sialic core of Papua-New Guinea". Many similar ultramafic bodies are found elsewhere in the world as large intrusions "closely connected with major tectonic features" (Ringwood, 1969). The most common ultramafic rocks in the series consists of forsterite rich olivine and orthopyroxene in approximate proportions 60-80% to 40-20% (Davies, 1968).

Carey (1938 a,b) attempted to reconstruct the gross tectonic evolution of the region, interpreting the present position of New Britain as due to an anticlockwise rotation in conformity with a global sinstral shear system transgressing the region. He regarded the Whiteman-Nakanai range axis of New Britain as "tectonically, structurally and stratigraphically ..... identical with the Toricelli chain of axials" comprising the north coast region. This hypothesis is regarded by Coleman (1966) as consistent with

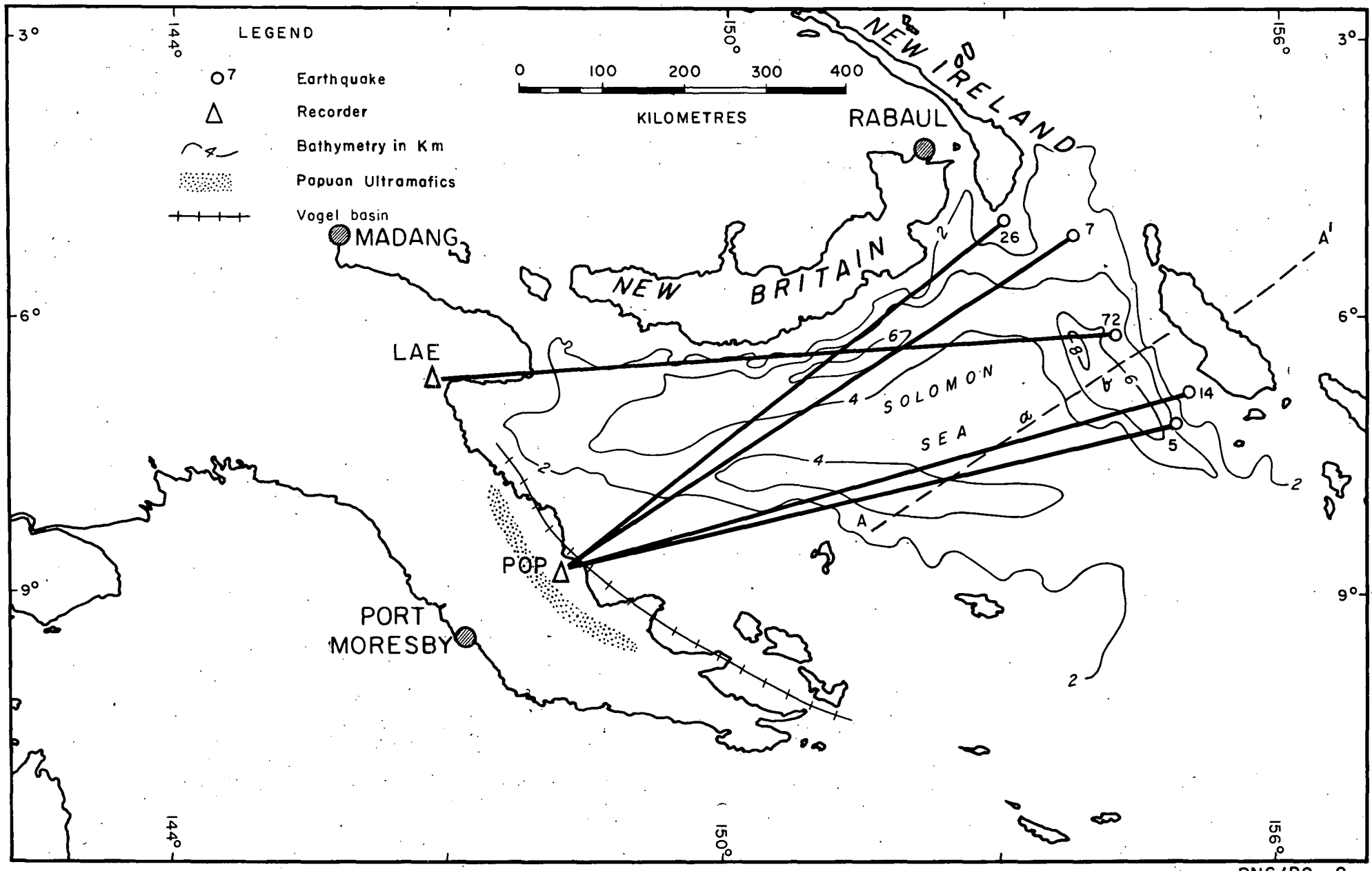

FIG.26 THE SOLOMON SEA. PATHS TO POPONDETTA AND LAE

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the "overall structure of the Solomons" region.

There is very little palaeomagnetic information available. Green and Pitt (1967) suggested that New Guinea has rotated anticlockwise from a meridional position since the Mesozoic. Manwaring (pers. comm.) firmly believes that anticlockwise rotation has occurred and has tentatively suggested an anticlockwise rotation of $110^{\circ} \pm 25^{\circ}$ during the early Tertiary and before the Miocene. He believes that subsequently, the surrounding islands including New Britain underwent further anticlockwise rotation of "up to another 90°". There is no information for any of the Solomon group including Bougainville.

The Solomon Sea crustal and upper mantle waveguide probably varies considerably from the uniform horizontally layered waveguide ideal for surface wave studies, and which is approximated more closely in southern New Guinea. Although about 700 km wide from southwest to northeast, the bathymetry (Fig. 26) varies from 0 to 8 km. On the basis that the Solomon Sea is composed of relatively new oceanic crust, one expects the central basin to be relatively thin compared with, say the south western margin beneath the Vogel Geosyncline and Papuan Coast, where St. John (1967) favours a depth to the M discontinuity of about 30 km.

4.1.1 Geophysical Data

St. John collated a Bouguer anomaly contour map of the Solomon Sea from a number of sources. This disclosed a platform of positive anomalies of less than 100 mg, north of the Vogel Basin, increasing to more than 400 mg in the central basin. There appears to be little regional gravity expression in the Planet Deep. Based on a crust-mantle density contrast of 0.5 gr/cc, and the correlations of e.g. Woollard and Strange (1962), associating thinning crust with increasingly positive anomalies and deepening ocean, St. John estimated that "the base of the oceanic crust

must be within a few km of the ocean floor" in the deeper trenches.

Rose, Woollard and Malahoff (1968) made provisional estimates of depths to the M-discontinuity at points a and b along profile AA' in Fig. 26. They assumed a continental standard crustal column of 32 km, a crustal density of 2.87 gr/cc and an upper mantle density of 3.3 gr/cc, and computed changes in depth as a function of water depth, free air anomaly and density contrast.

Values of 10, 13 km found for points a, b increase by about 2 km if a 1 km sediment layer is included. Rose et al compare these with provisional depths from seismic refraction of about 13 and 16 km respectively.

Apart from the provisional nature of these interpretations, the important source of error concerns the assumption of 0.46 gr/cc density contrast at the M-discontinuity. A variation of, say 0.1 gr/cc in contrast would affect the depth estimate by about 2 km or so.

The only indications of mantle density arise from refraction experiments. Khan and Woollard (1968) reported P_n velocities from 7.7 to 8.1 km/sec. in the central basin area. Wiebenga et al (in prep.) discovered even greater variations from 7.7 to 8.8 km/sec in the region around northern New Britain. If such a range is characteristic of the general Solomon Sea region, one might expect densities to vary from about 3.3 to more than 3.6 gr/cc.

4.2 OBSERVED DATA

Earthquakes selected for analysis are listed in Table 11. These all occurred on the north or north-east margin of the Solomon Sea and were recorded at Popondetta, Lae, or Tapini. Figure 26 shows epicentre to station paths with a maximum "over-ocean" percentage content where the recorders at

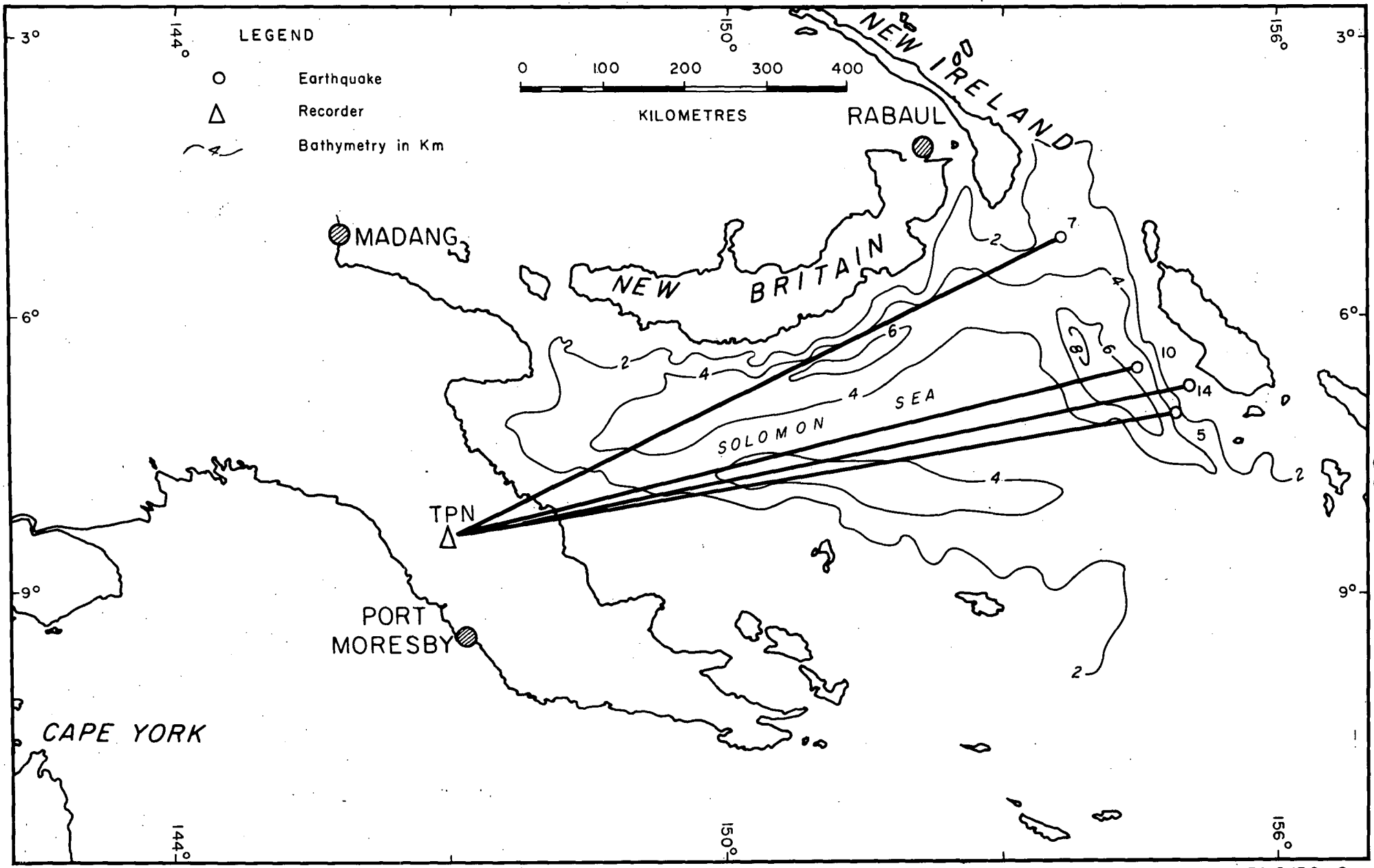

FIG. 27 PATHS TO TAPINI

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Lae or Popondetta were employed, whereas paths to Tapini, containing a small but significant continental component are illustrated in Fig. 27.

Epicentral distances are only about half those employed in the study of southern New Guinea, and consequently the alternative dispersion curves, corresponding to $\Delta\phi_o = \pm n\pi/2$ are more widely spaced.

Typical seismograms are reproduced in Fig. 28. Apart from the prominent fundamental mode Rayleigh waves, noticeable dispersion follows the P wave arrival, and is classified as a PL ("Leaking mode") wavetrain. The range of focal depths extends to less than 100 km and no higher modes were detected in these data.

TABLE 11

EVENT	ORIGIN G.M.T.	LAT (°S)	LONG (°E)	DEPTH (KM)	MAG. USCGS	STATION	Δ (KM)	AZ (°)
5 Oct. 8, 1965	03 32 52.8	7.1	154.9	85	5.1	POP	750	255.7
						TPN	879	260.4
7 Sept. 3, 1965	21 38 53.6	5.2	153.7	54	-	POP	713	236.7
						TPN	815	244.4
10 Jan. 10, 1966	16 12 14.8	6.6	154.5	64	5.2	TPN	847	256.4
14 July 27, 1965	15 53 44.1	6.8	155.1	86	5.5	POP	780	253.8
						TPN	906	258.6
26 June 28, 1965	03 33 36.5	5.1	153.0	50	6.1	POP	657	232.3
72 Apr. 30, 1967	23 06 16.1	6.2	154.2	72	4.7	LAE	803	265.9

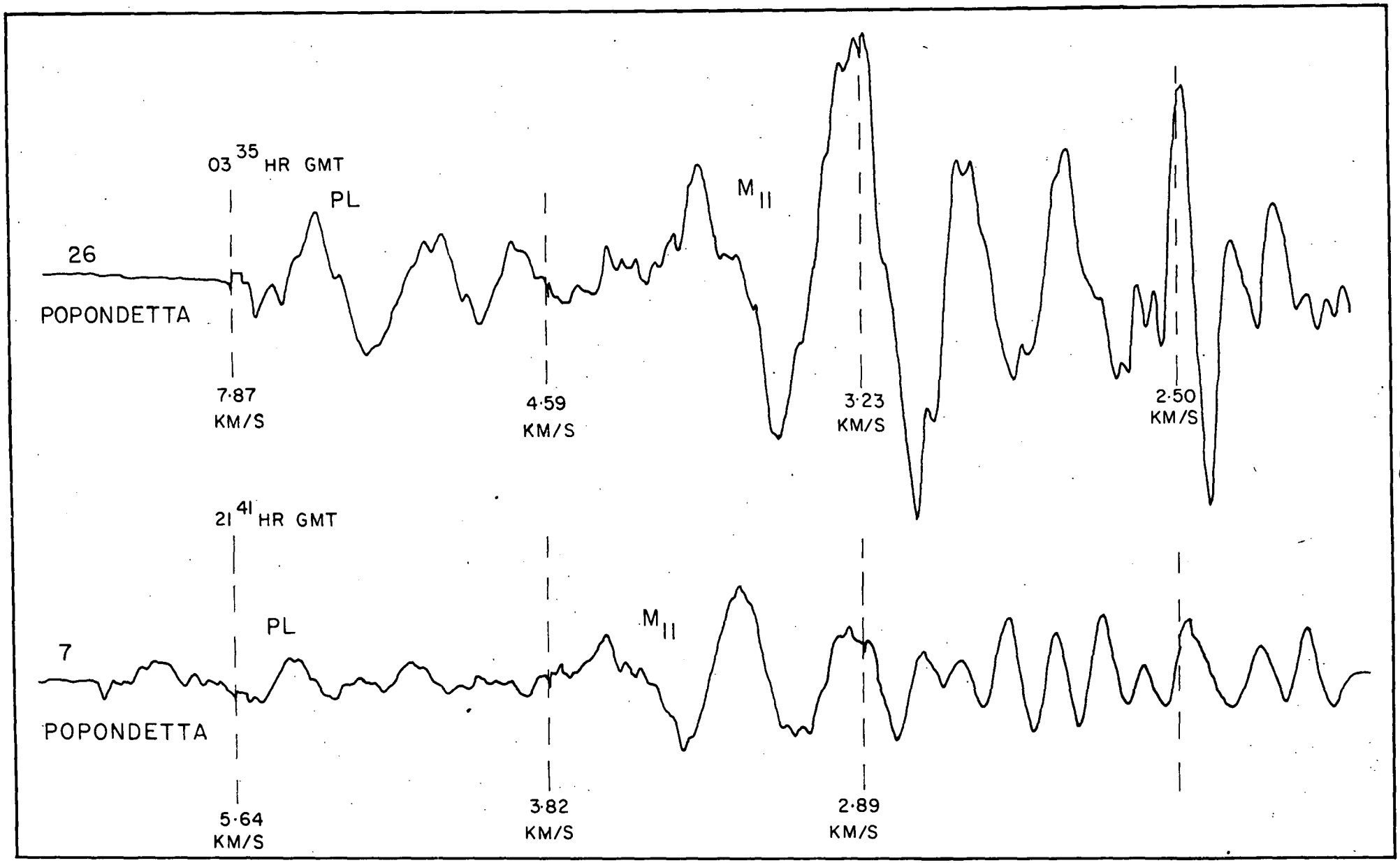

FIG. 28 TYPICAL SEISMOGRAMS USED IN THE STUDY OF THE SOLOMON SEA REGION

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4.3 PHASE VELOCITIES

4.3.1 Paths to Popondetta

Sets of alternative phase velocities corresponding to paths in Fig. 26 are shown in Fig. 29, together with standard deviations from 4th or 5th order polynomials fitted to each of four sets of data in a least squares sense. In the diagram only points for two sets are plotted, and set II symbols have been filled for clearer distinction from those of set III.

Two features of the diagram should be noticed. Firstly, in the period range above 20 to 25 sec. the scatter within each group, indicated by the standard deviations, is significantly less than the separation of the groups - ref. section 2.3.1. Secondly, there is little evidence that profiles for each event, within each set I, II, III are displaced parallel to each other. This is expected if errors of distance and origin time influence the scatter of points more than small errors in ϕ_o and variations in crustal structure - ref. section 2.3.1 above.

The grouping of sets of dispersion curves corresponding to $\phi_o = \pm n\frac{\pi}{2}$ is more clearly apparent than was the case for the longer paths employed for the southern New Guinea study. The range of epicentral distances, from shortest to longest path, is not large and it is extremely difficult to distinguish the correct dispersion region from the relative separation of the members within each set, with any degree of confidence. Relative separation of individual profiles is not a good criterion as paths differ in length only by a maximum of 150 km. Events 14 and 26 are most suitable for this test and match best in set II. The profile for event 14 is below that for 26 in set I and above it in set II.

In the circumstances, the standard deviations shown in Figure 29 provide the best guide to profile selection (section 2.2.3 (b)). These are smallest for sets II and III viz. .021 and .022 km/s respectively. These

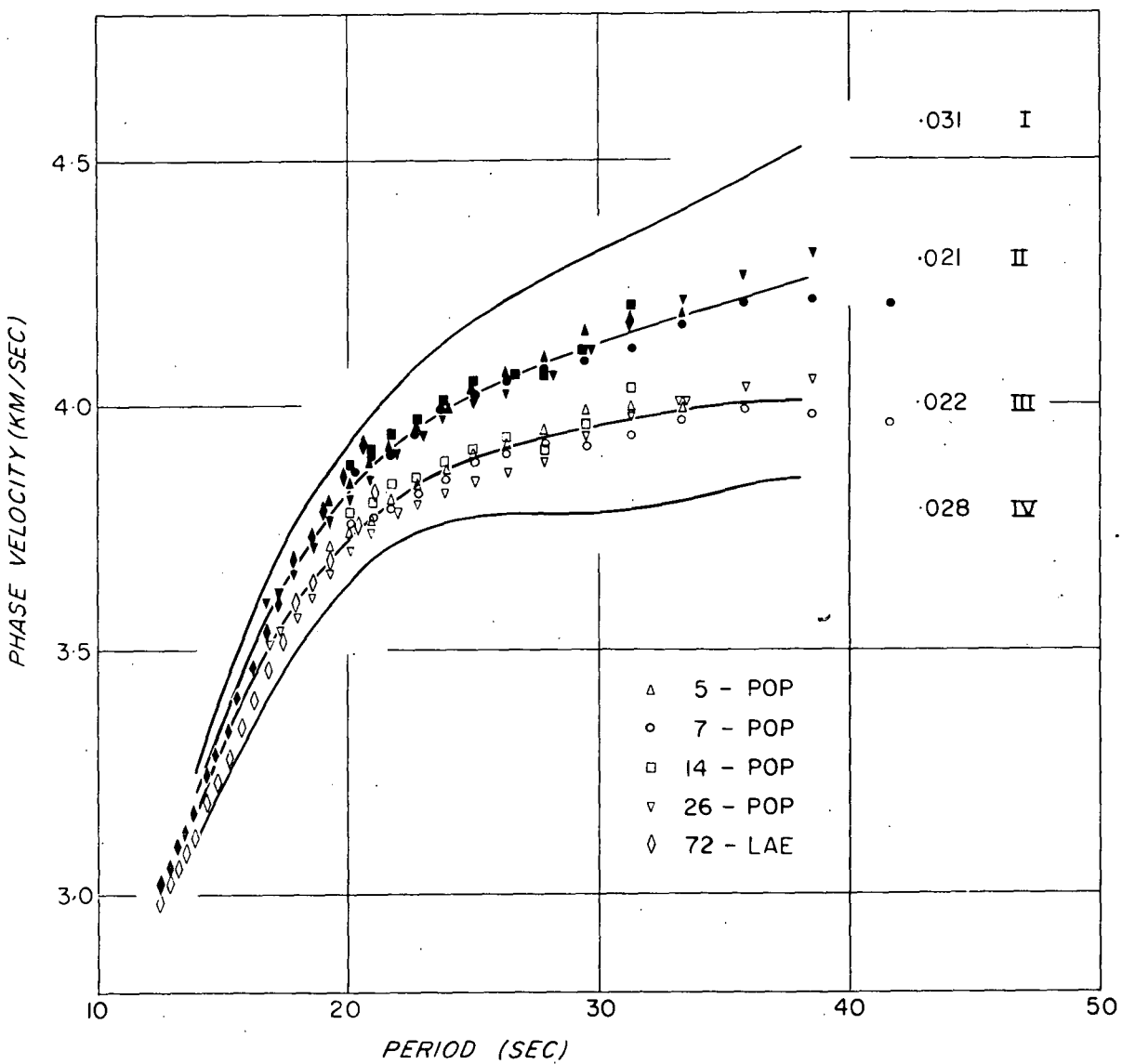

FIG. 29 DISPERSION PROFILES FOR PATHS SHOWN IN FIGURE 26

S.D IN KM/SEC, FROM POLYNOMIALS SHOWN AS SOLID LINES, ARE ADDED AT THE RIGHT HAND END.

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sets therefore, are interpreted to define approximate upper and lower limits of the region containing the correct dispersion profile for the Solomon Sea waveguide. Phase velocities are listed in Table 12.

TABLE 12

Phase Velocities for Profiles in Fig. 29

Phase Velocity (km/s)

T (SEC)	II (1)*	II (2)*	III (1)	III (2)	IV (1)	IV (2)
40.0			3.995	4.023	3.808	3.856
38.0	4.257	4.201	4.006	4.012	3.848	3.846
36.0	4.223	4.187	4.003	4.000	3.836	3.834
34.0	4.190	4.171	3.992	3.986	3.809	3.821
32.0	4.157	4.152	3.976	3.970	3.787	3.807
30.0	4.126	4.128	3.958	3.950	3.777	3.790
28.0	4.091	4.097	3.936	3.927	3.776	3.770
26.0	4.051	4.057	3.907	3.898	3.776	3.745
24.0	3.997	4.003	3.867	3.859	3.762	3.715
22.0	3.924	3.927	3.809	3.806	3.720	3.674
20.0	3.821	3.817	3.723	3.730	3.637	3.617
18.0	3.678	3.663	3.598	3.612	3.507	3.528
16.0	3.482	3.464	3.420	3.428	3.330	3.375
14.0	3.219	3.238	3.174	3.164	3.119	3.096

* (1) Fitted polynomial

(2) Phase velocity for model matched to (1)

When considering these changes in standard deviation, it should be remembered that factors controlling these differences from one profile to another, are exactly known as they result from changes in "travel time"

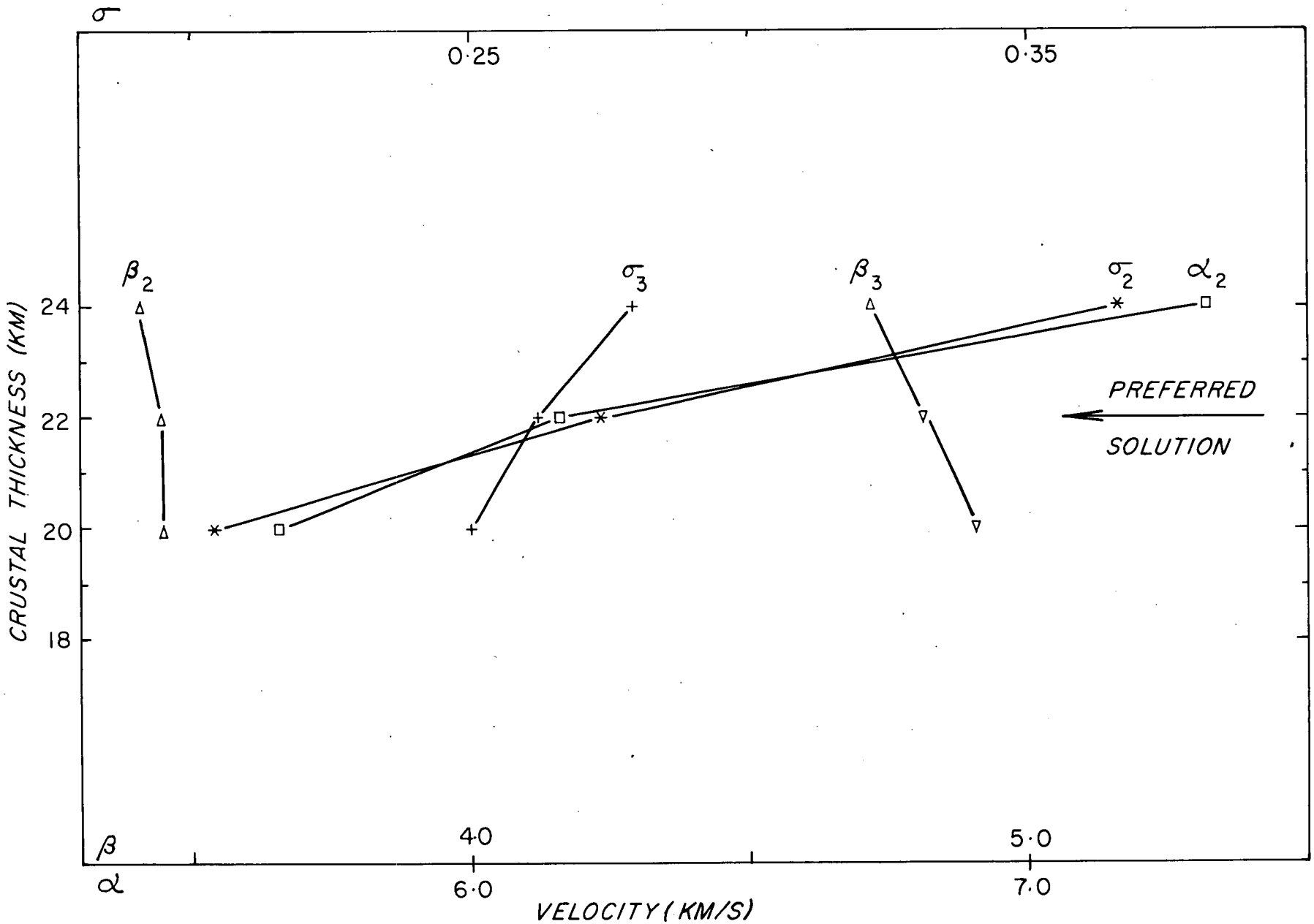

FIG. 30 INVERSION SOLUTIONS FOR PROFILE II OF FIG 29

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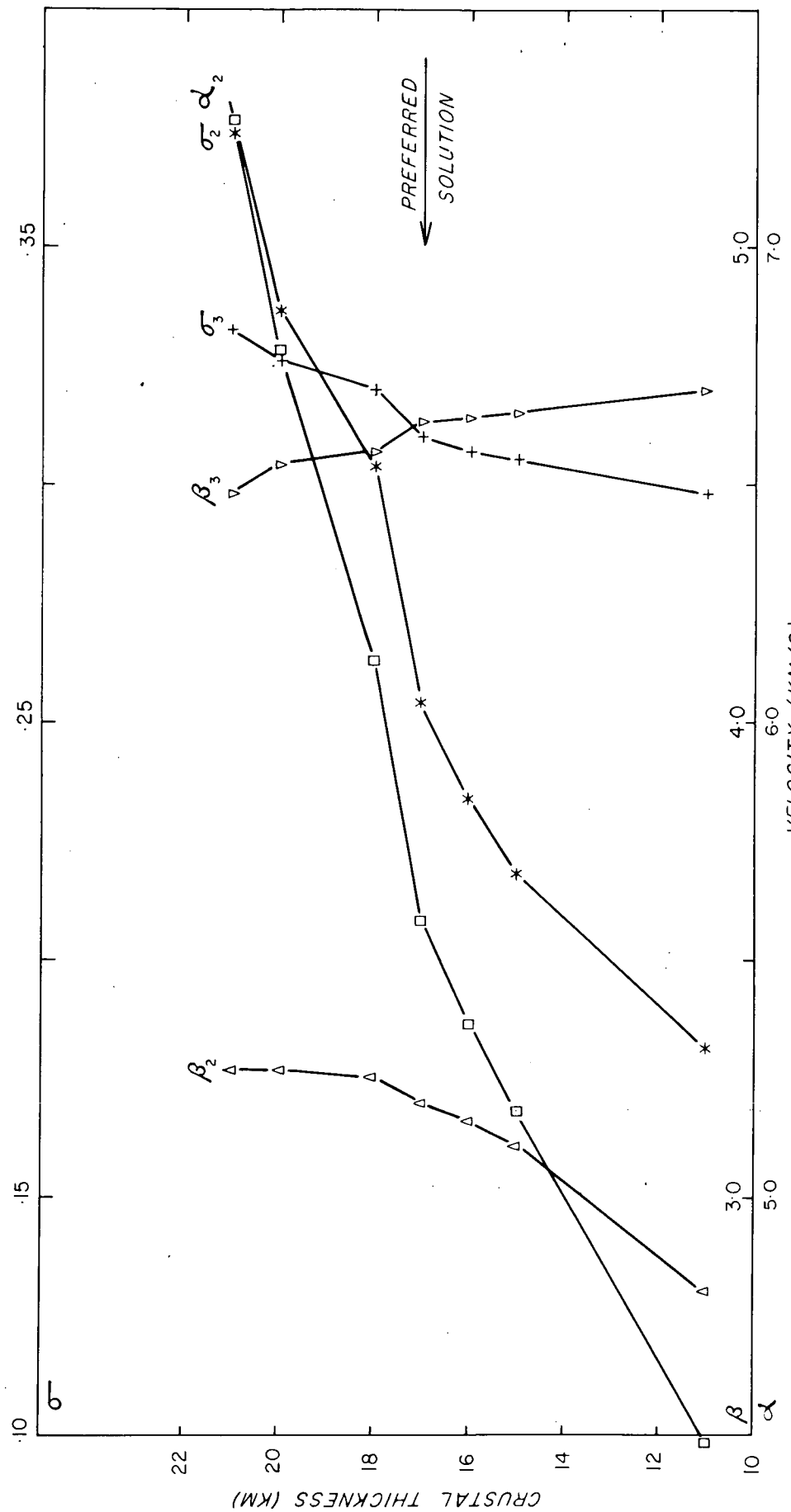

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FIG. 31 INVERSION SOLUTIONS FOR PROFILE III OF FIG. 29

introduced by variations of $\pi/2$ in source phase. In general, the data fitted by these polynomials was listed to 3 decimal places. Consequently, smooth behaviour of the standard deviation from one profile to the next can be expected at a level of about .0005.

A tendency of the profiles to exhibit an "oceanic" type shape is worth noting. This is characterised by a rapid increase in velocity at short periods, a consequence of a thinner crust than, say, in the case of the southern New Guinea profiles, and the presence of a water layer at the top of the waveguide.

The Poisson's ratio criterion was employed to determine preferred inversion solutions for profiles II, III, IV in terms of the simplest model available. The models include a water layer of 4 km thickness, considered to be a representative depth of the ocean basin, a crustal layer and a semi-infinite upper mantle layer. Reduction diagrams for polynomial II, III are shown in Fig. 30, 31 respectively and model solutions for profiles I, II and III are listed in Table 13. These show a range of upper mantle shear velocities from 4.4 to 4.8 km/sec. and crustal thickness from 13 to 22 km.

The values of floating parameters for set III are close to the averages of corresponding parameters from sets II and IV, as predicted in section 2.2.7. The small disparity is attributed to small differences in partial derivatives for models II and IV. Hence in defining a dispersion range for the Solomon Sea waveguide, models II and III also define ranges for model parameters.

4.3.2 Paths to Tapini

Sets of dispersion curves for paths shown in Fig. 27 are plotted in Fig. 32. Standard deviations from fitted polynomials are larger than in Fig. 29 and indicate a slight preference for set II, although there is no

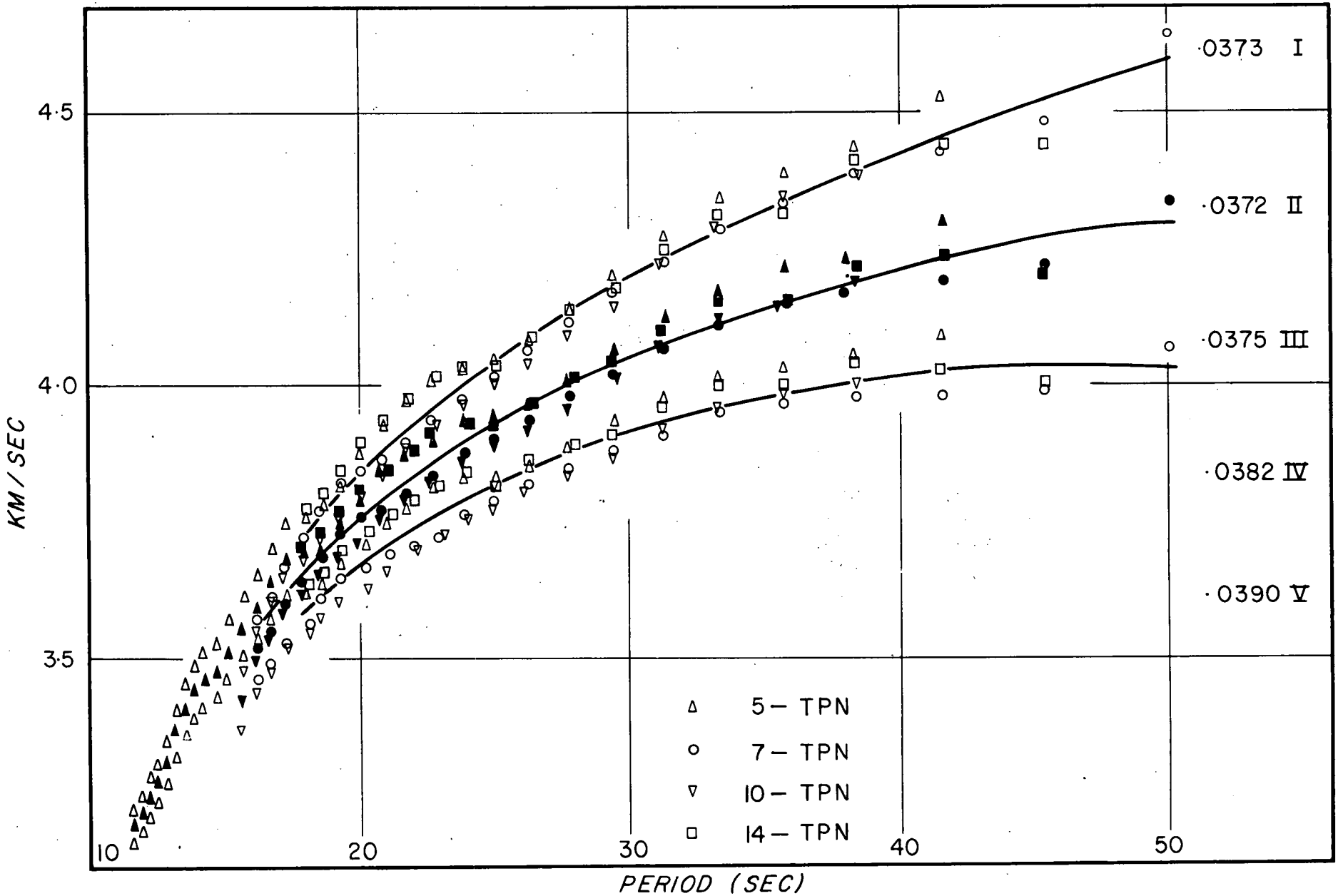

FIG. 32 DISPERSION FOR PATHS TO TAPINI

PNG/89-21

clear choice between any of the three sets shown. One would expect phase velocities for periods above 30 to 40 seconds to converge on velocities for paths to Popondetta (section 4.3.1), as the paths in Figs. 26, 27 share a common waveguide and differences should decrease with depth of penetration. Polynomial coefficients are listed in Appendix VIII.

TABLE 13

Model Parameters for profiles of Fig. 29

Data Profile	Thickness km	km/s	km/s	gr/cc	
II	4.0	1.52	0.00	1.03	
	22.0 *	6.16 *	3.44 *	2.80	.274
	-	8.50	4.82 *	3.32	.263
III	4.0	1.52	0.00	1.03	
	17.0 *	5.57 *	3.20 *	2.80	.254
	-	8.00	4.62 *	3.32	.250
IV	4.0	1.52	0.00	1.03	
	13.0 *	5.08 *	2.84 *	2.80	.273
	-	7.90	4.40 *	3.32	.275

* Floated parameter

Phase velocities in Fig. 32 (set II) decrease less rapidly with periods below 20 sec. than in Fig. 29. Data were not inverted in terms of models as the mixed nature of the paths lessens any physical significance of such models. The continental component of paths to Tapini tends to decrease average travel times at short periods and raise this portion of the dispersion curve. Moreover, the effects of back reflections from structure "behind" Tapini, i.e. a thinning crust south of the Cordillera

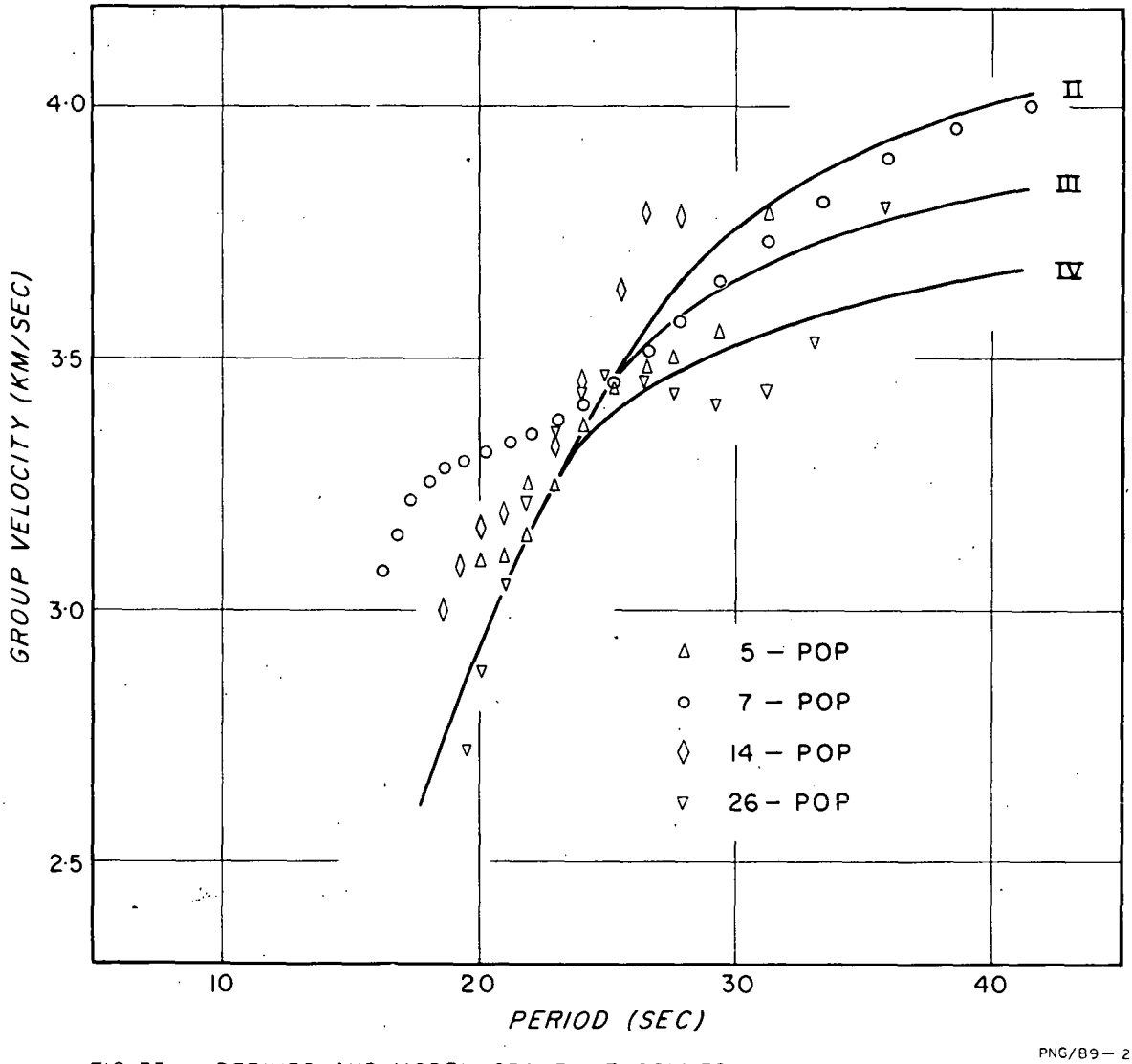

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FIG. 33 DERIVED AND MODEL GROUP VELOCITIES FOR PATHS SHOWN IN FIGURE 26

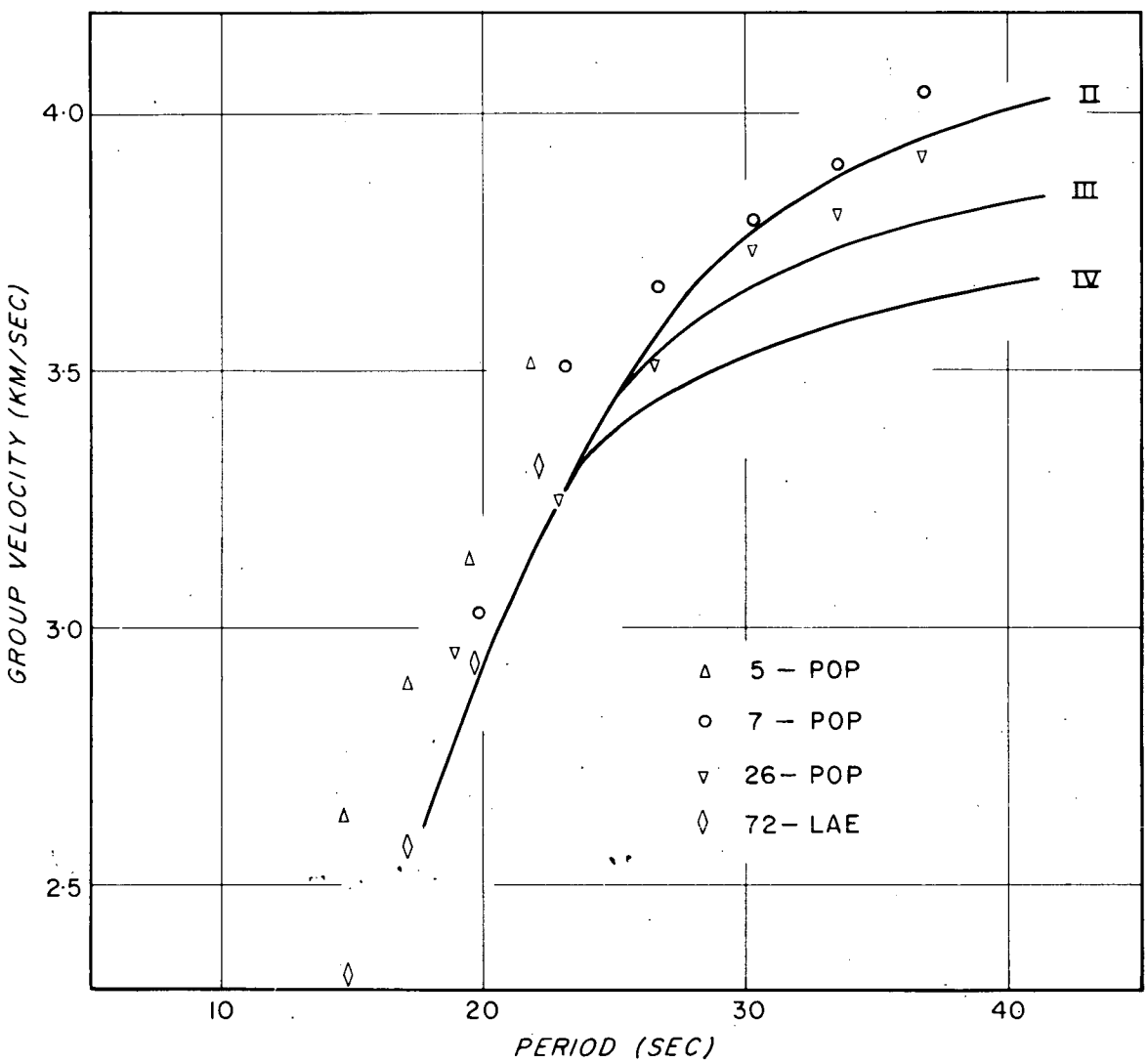

FIG. 34 HAND ANALYSED, AND MODEL GROUP VELOCITIES FOR PATHS SHOWN IN FIGURE 26

PNG B9-23

axis and away from the epicentre, is shown by the irregular or quasi-sinusoidal characteristic of the dispersion for events 5, 7, 14 (Fig. 32). This is not so evident in Fig. 29. Such effects may be weaker for these paths, as Popondetta is further from the Cordilleran axis and hence, travel times and attenuation of any reflected waves would be greater.

4.4 GROUP VELOCITIES

Group velocities, found from polynomials fitted to the phase velocity data in the Chebyschev sense, are plotted in Fig. 33, for paths to Popondetta. Group velocities evaluated by hand techniques, applying the group delay correction in the manner described by Thomson and Evison (1962), are shown in Fig. 34.

These diagrams also show model group velocities for the model solutions in Table 13, and confirm that upper mantle shear velocities for the region are probably between 4.8 and 4.6 km/sec. found from the reduction of profiles II and III respectively. Likewise thicknesses of the crustal layer of between 17 and 22 km are indicated.

The smoothest profiles extending over the greatest period range are provided by events 5, 7 (Fig. 29).

Any slight departure from smoothness in the dispersion e.g. for events 14, 26 in Fig. 29 are greatly magnified in the derived group velocity profiles, Fig. 33.

Derived group velocities for paths to both Tapini and Popondetta are compared in Fig. 35. Group velocities at about 40 seconds period are close and this agreement supports the interpretation in section 4.3 tying dispersion profiles for both paths to equal phase velocities at long periods.

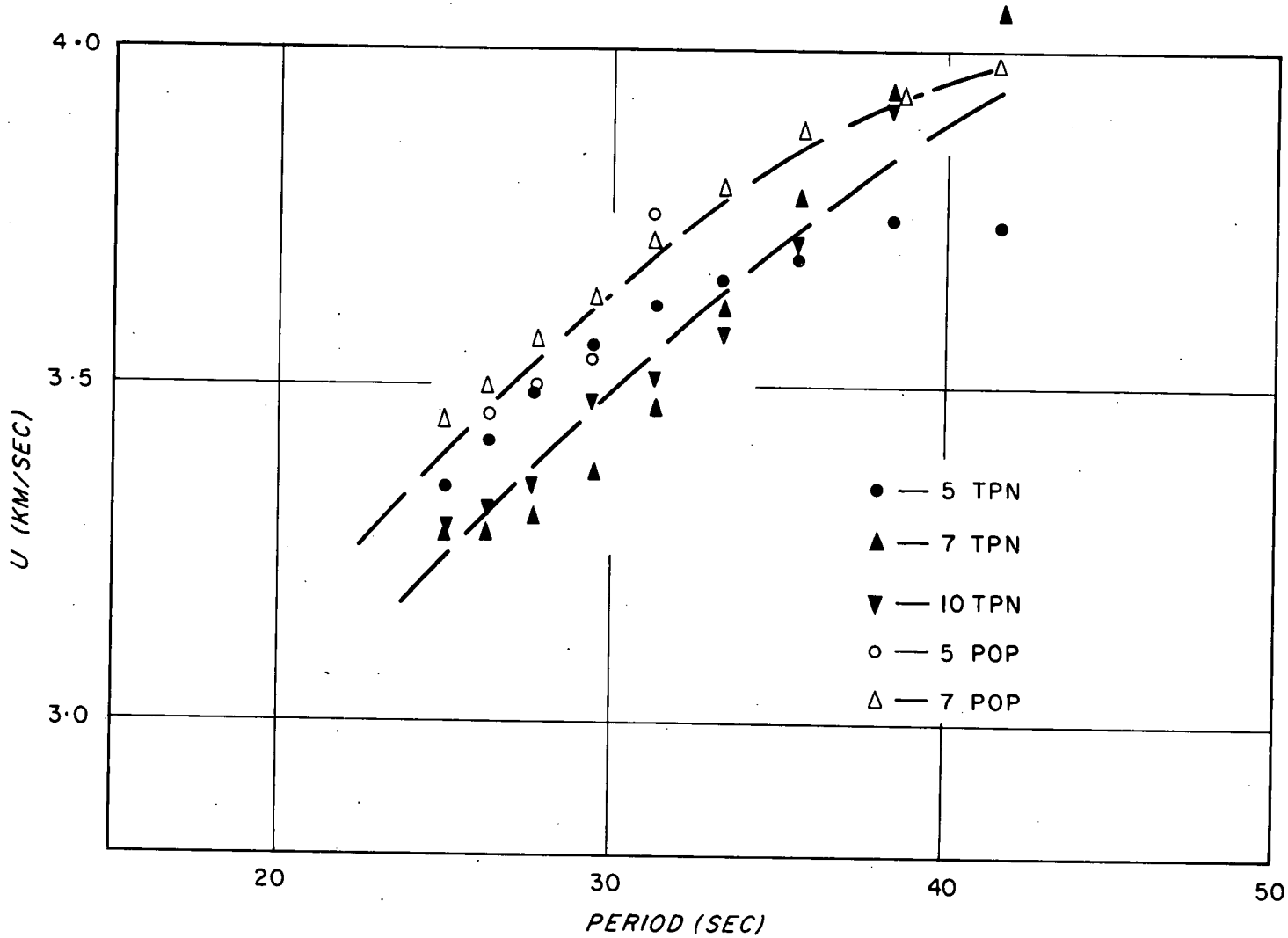

FIG. 35 GROUP VELOCITIES FOR PATHS TO POPONDETTA AND TAPINI

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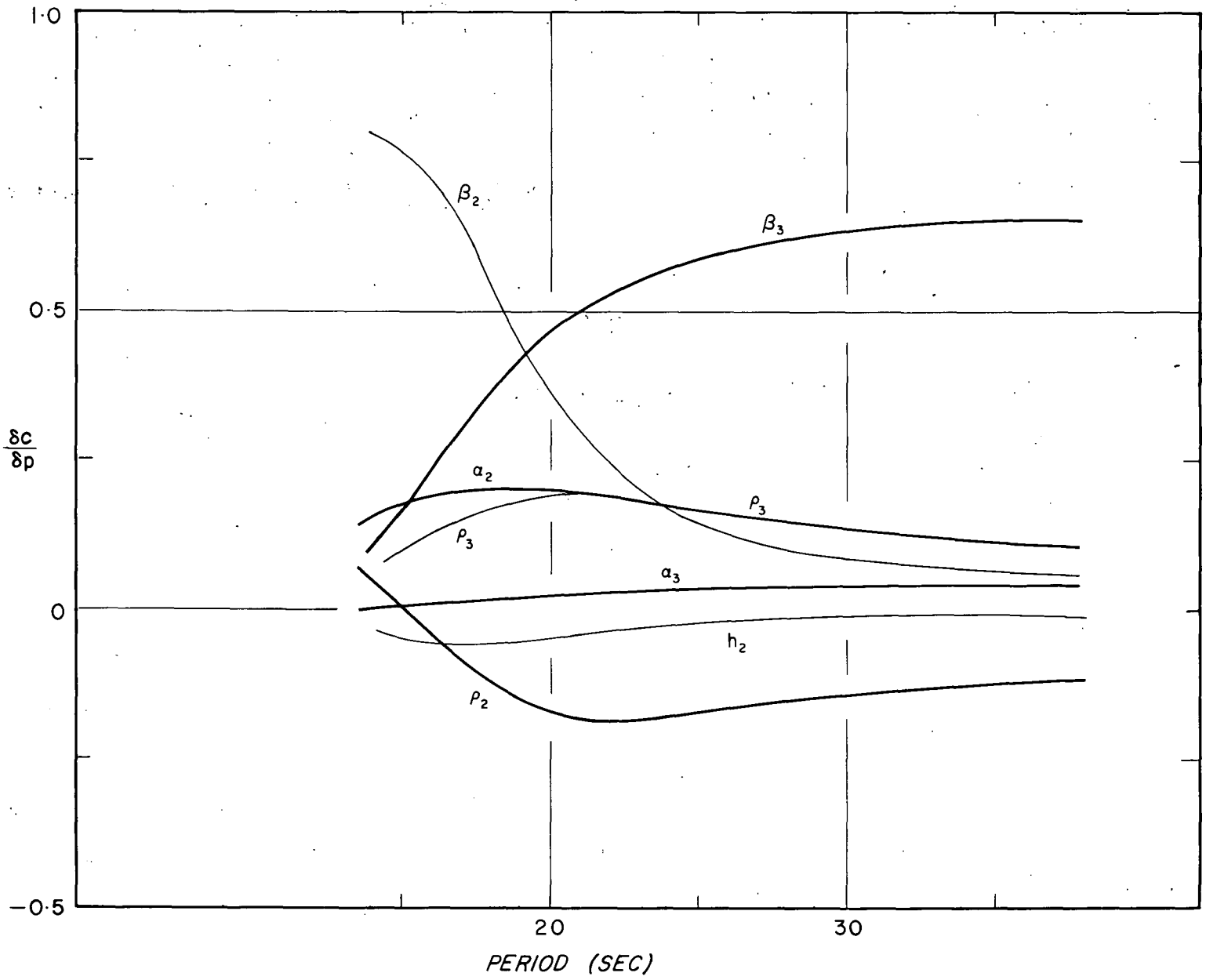

FIG 36. SENSITIVITY OF PHASE VELOCITY TO MODEL WAVEGUIDE PARAMETERS, $\frac{\delta c}{\delta p}$ FOR THE SOLOMON SEA. ORDINATE SCALE IS KM/SEC PER KM/SEC, gr/cc, OR KM AS APPROPRIATE.

PNG/B9—72

4.5 DISCUSSION

The most significant feature of the models in Table 13 is the high upper mantle shear velocity of 4.6 to 4.8 km/sec. Both models differ by 5 km in crustal thickness, which is of less significance as phase velocity is more sensitive to shear velocity than to thickness (Fig. 36).

The effective penetration of Rayleigh waves having periods up to 40 seconds is about 50 km (depth to half maximum vertical displacement) so this velocity might be regarded as representative of material between the crust and this depth.

These shear velocities are in marked contrast with values of 4.4 to 4.5 km/sec. for the southern New Guinea upper mantle. The discrepancy of about 0.2 km/sec. is highly significant, but cannot be attributed either to pressure differences - crustal thickness differences of, say, 15 km imply a 5 kb pressure difference, or to temperature.

Anderson, et al (1968) list some derivatives of shear velocity with respect to pressure and temperature. Accepting those for forsterite as representative of the upper mantle viz.

$$\left(\partial\beta/\partial P\right)_T = .002 \text{ km sec}^{-1} \text{ kb}^{-1}$$

$$\left(\partial\beta/\partial T\right)_P = -.0003 \text{ km sec}^{-1} {}^{\circ}\text{C}^{-1}$$

it is clear that changes of 100 kb in pressure or about 1000°C in temperature change are required to cover the discrepancy, which is discussed further in Chapter 9.

The crustal thickness of 17 to 22 km is a representative figure for the whole waveguide. Beyond believing it to be a reasonable figure, given a minimum thickness of say 10 km in the central basin and 30 at the southern end of the path from gravity data, further discussion is not warranted.

5. NEW BRITAIN

This region is discussed only briefly. Dispersion characteristics of paths crossing New Britain are compared with those for the Solomon Sea. The crust and upper mantle beneath paths which include part of New Britain are geometrically and structurally heterogeneous and are therefore unsuitable for detailed study by these methods.

5.1 PHASE VELOCITIES

Fig. 37 shows paths crossing New Britain and ending at Tapini, which were available for analysis. Several factors exist to perturb otherwise smooth dispersion curves. Apart from the expected complexity of the structure beneath New Britain, the paths intersect two structural boundaries south of New Britain mainland, and are not normal to the boundary of the New Britain structural unit. The crust south of the recorder at Tapini probably thins near to the south coast of New Guinea, and may cause back reflection interference effects on some wavetrains.

Consequently phase velocity profiles for slightly different paths will exhibit more variability than for a less heterogeneous structure such as the Solomon Sea. Profiles for individual earthquakes will not be as smooth, and the standard deviation for a group of profiles will be larger than in, say, Fig. 27.

Eight earthquake records were analysed and four sets of profiles are shown in Fig. 38. The general scatter of points grouped as sets II and III are shown as filled and open circles respectively. Individual paths are not identified in this presentation. Errors in path length or origin time are not large enough to obscure a clear grouping of points for periods greater than, say, 25 seconds, as predicted in section 2.3.1.

The standard deviations are about twice those in Fig. 27, change only slowly and are smallest for profiles III and IV, the fourth decimal

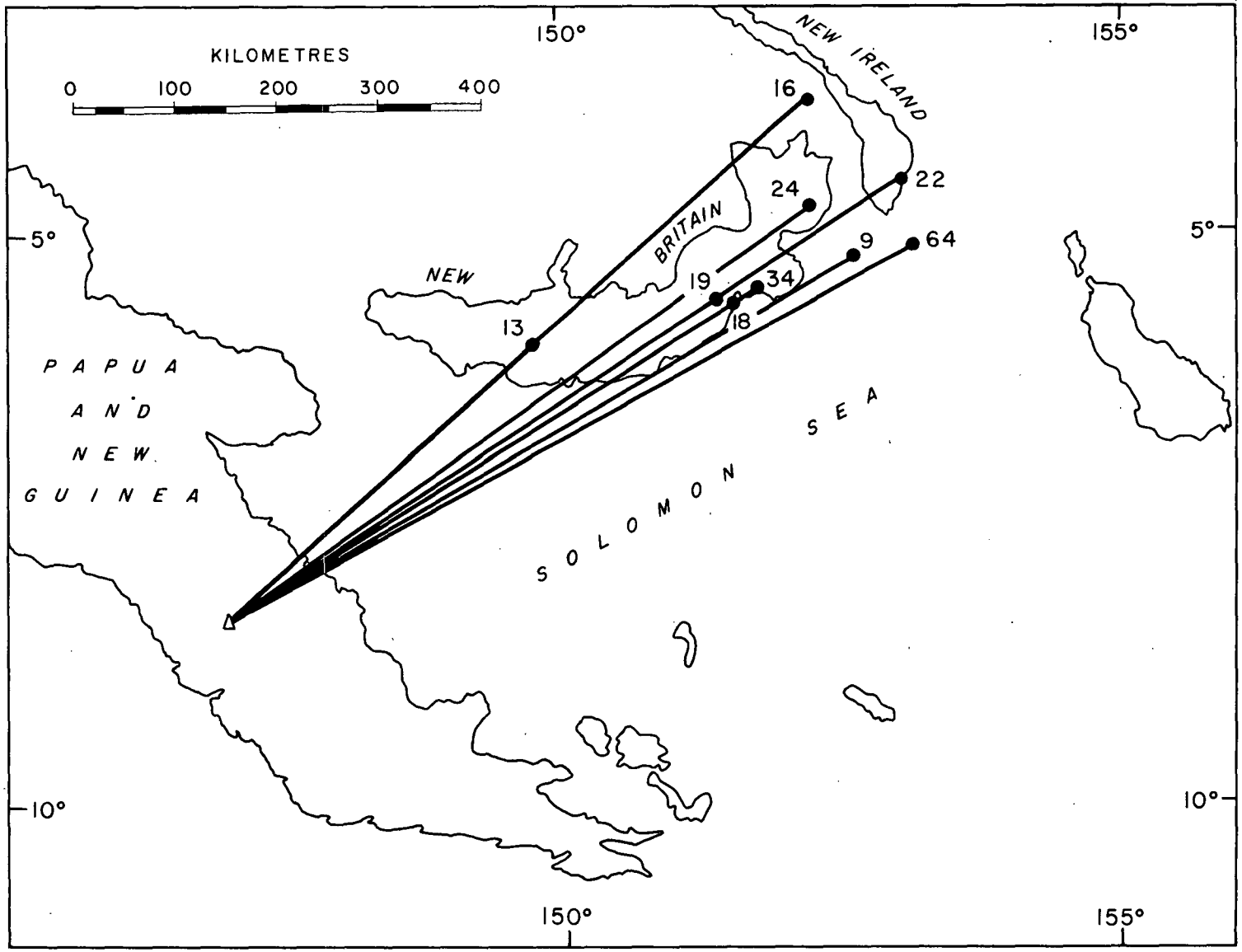

FIG. 37 PATHS TRAVERSING NEW BRITAIN

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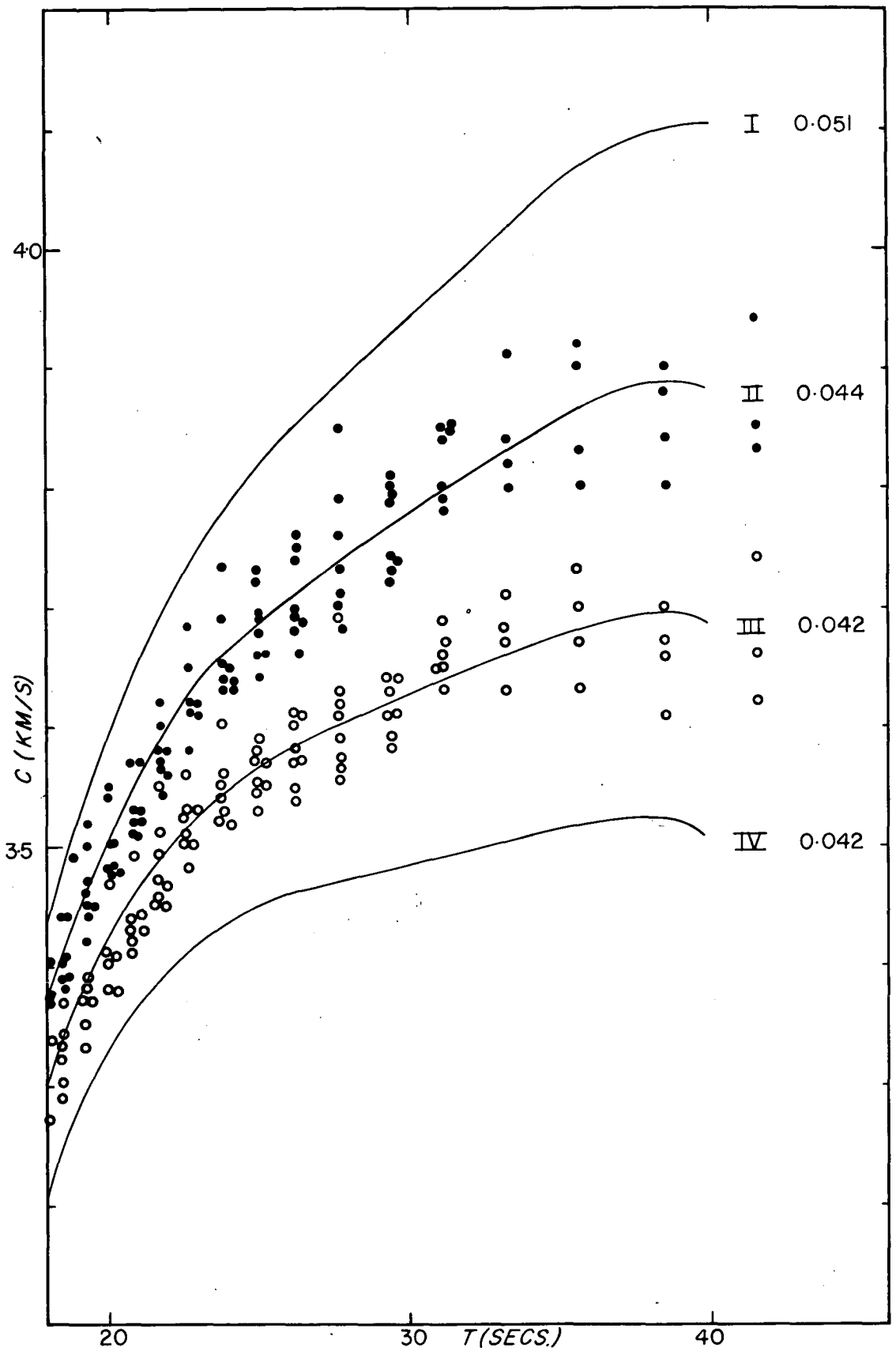

FIG. 38 FOUR GROUPS OF DISPERSION PROFILES PNG/B9-13

POLYNOMIALS ARE DEFINED IN APPENDIX VIII

place favouring profile III. Three pairs of profiles have also been selected and their relative separations examined. These should reverse in the region of profile III if consistent with the minimum standard deviation.

Pairs of events 18,22; 34,64; 22,34 having different path lengths but common segments are grouped in Figs. 39a, 39b, 40 respectively.

In Fig. 39a the relative separation of points reverses between sets II and III. In Fig. 39b, reversal occurs near set III and in Fig. 40 between sets III and IV.

The most significant feature of the region of the phase velocities near profile III is that phase velocities at long periods are much lower than for Solomon Sea paths. The effect of any crustal thickening beneath New Britain cannot be seen here, but the lower phase velocities at long periods do imply lower upper mantle shear velocities.

Inversion of phase velocity profiles III and IV was not attempted. Parameters found would have little significance in view of the heterogeneous nature of the structures involved.

5.2 GROUP VELOCITIES

Group velocities were evaluated by polynomial differentiation for paths 13, 16, 24 to TPN and are shown in Fig. 41. The profile for event 16 is perturbed, reflecting a corresponding smaller amplitude perturbation in the phase velocity profile.

Model group velocity dispersion profiles enclosing the dispersion region covered by Solomon Sea paths, also shown in Fig. 41 are clearly higher at longer periods than the group velocities plotted. This supports the conclusion reached from phase velocity data that shear velocities beneath the New Britain crust are probably lower than those beneath the Solomon Sea.

Both sets of group velocities converge with increasing period, and a common dispersion region probably exists at periods of about 50 sec. or

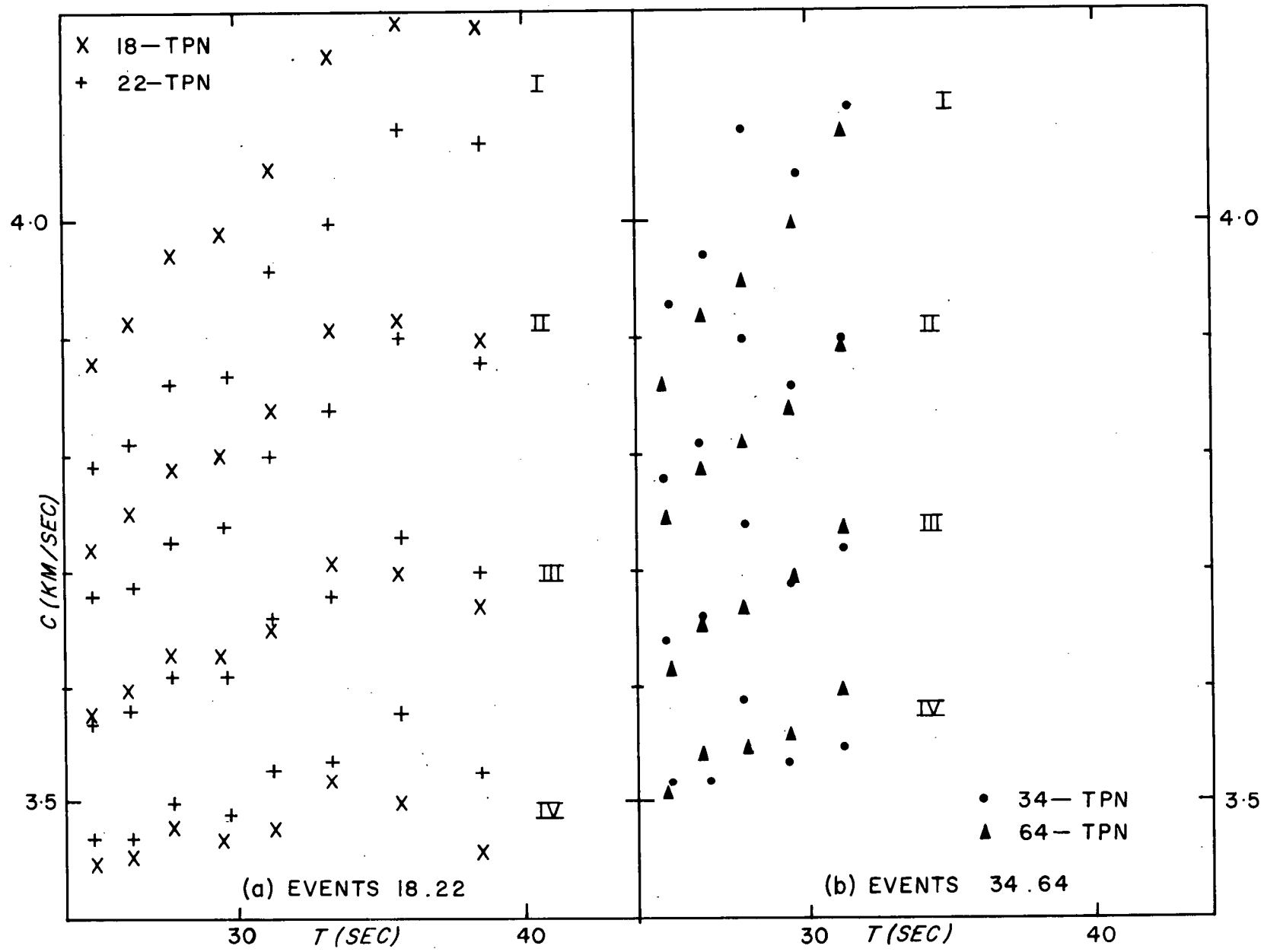

FIG 39. RELATIVE SEPARATION OF ALTERNATIVE PROFILES

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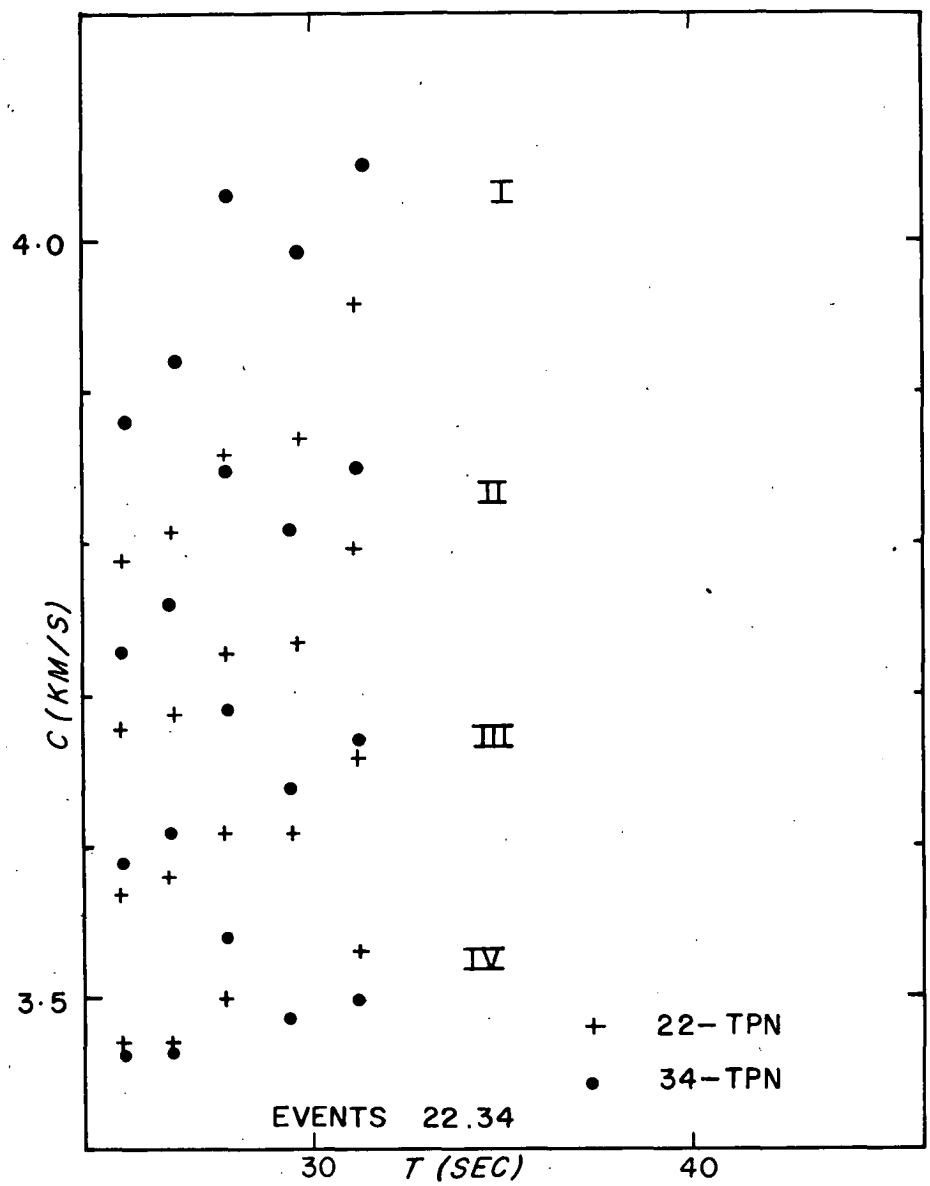

FIG 40. RELATIVE SEPARATION OF ALTERNATIVE PROFILES

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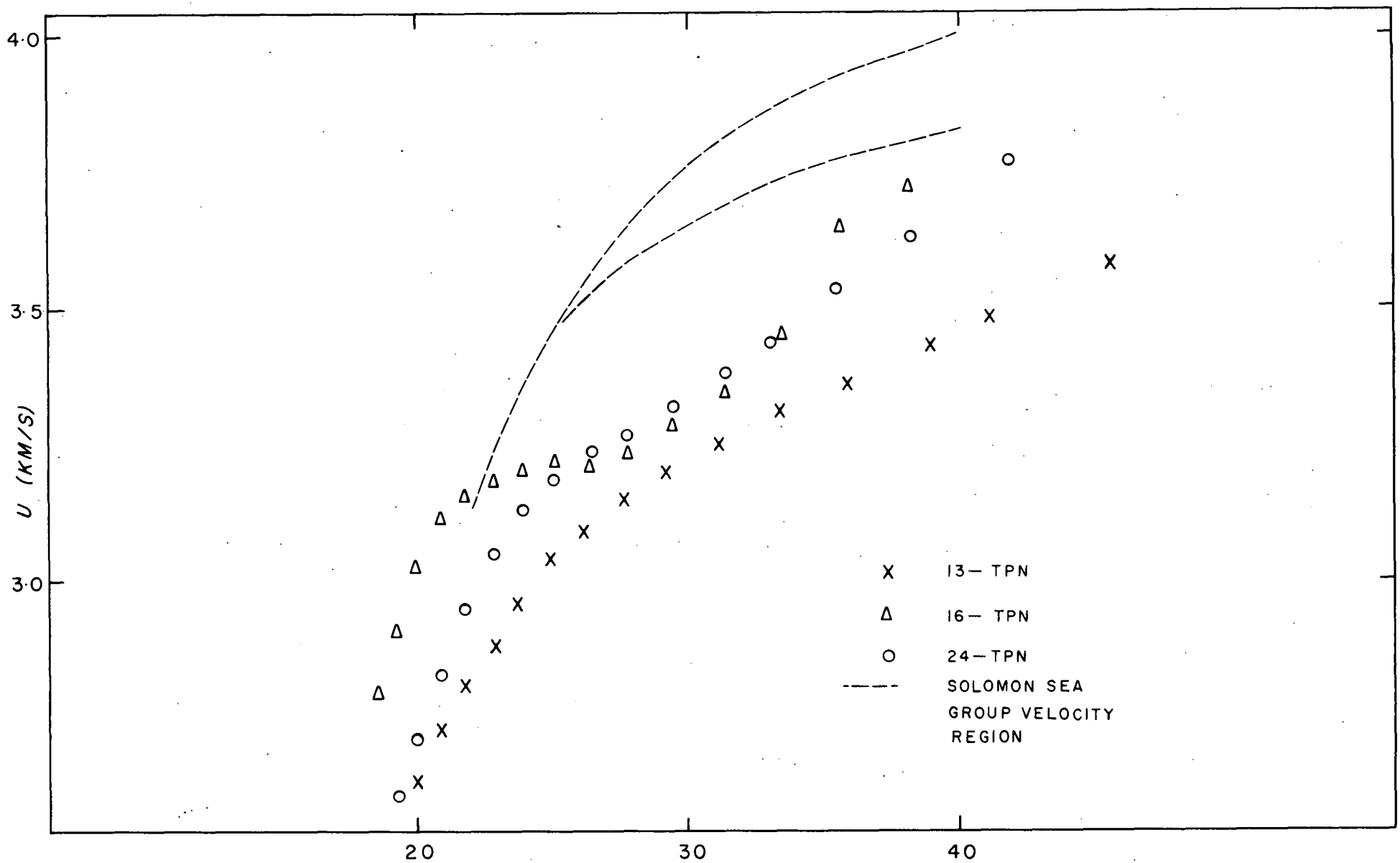

FIG. 41 COMPARISON OF GROUP VELOCITIES FOR PATHS INCLUDING NEW BRITAIN AND THOSE FOR PATHS CONFINED TO THE SOLOMON SEA.

PNG/B9-16

greater. Penetration of waves in the period range 40-60 seconds can be gauged from Fig. 25, Chapter 3. Vertical displacement for a 50 sec. period wave decreases to half maximum amplitude at about 100 km. The corresponding depth for a 40 sec. period wave is about 80 km.

Hence one suspects that shear velocities beneath the Solomon Sea and New Britain are probably the same below about 80 km depth.

6. NORTHERN REGION

6.1 GEOLOGY AND TECTONICS

The northern region discussed in this chapter refers to the land mass between the two major systems of mountain ranges in New Guinea, having the general axial trends marked in Fig. 42. The central cordillera forms a southern margin, and the northern chain of ranges, approximately en echelon, and the northern littoral, form the northern margin. This northern chain includes the Toricelli, Prince Alexander, Adelbert, Sarawuged and Finisterre Ranges, marked respectively T, P, A, S, F in Fig. 42.

The northern region essentially comprises the central intermontane, a major structural trough incorporating the central plains of West Irian, the Sepik intermontane and the Ramu and Markham River valleys, respectively marked (1), (2) and (3) in Fig. 42.

Both major mountain systems, to the north and south, contain cores of crystalline rocks thought to be Mesozoic or older. They were uplifted in a major orogenic phase which began in the middle to late Tertiary and is probably still active (Smith, 1965). Carey (1938b) described the northern littoral as a region "of positive active elevation" in contrast to the subsiding and generally stable southern littoral.

The regional Bouguer anomaly map produced by St. John (1967) and the profile discussed by Visser and Hermes (1962) are the only geophysical data yet produced which are strongly influenced by the deep crust and upper mantle. St. John's map disclosed extensive areas of negative anomaly reaching -160 mg, throughout the region from the Huon Peninsula westward to the 141st meridian. A zone of positive anomalies begins northward of latitude $3\frac{1}{2}^{o}$S (Fig. 42). St. John concluded, from his interpretation of several NE-SW trending profiles across the region, that the gravity data were consistent with a depth to the M discontinuity varying from 35-40 km to about 30 km. He used a density contrast of 0.5 gm/cc at the M discontinuity.

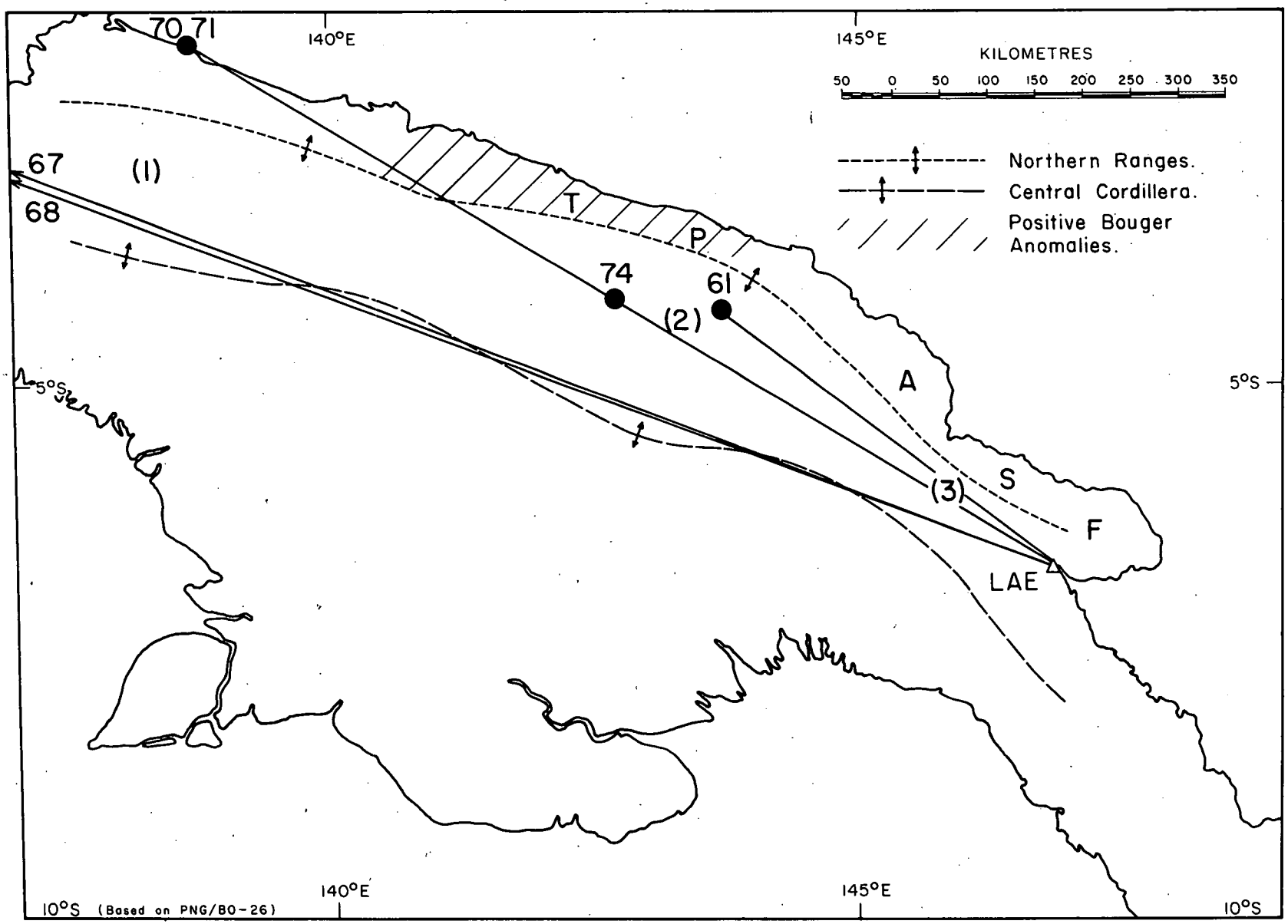

Fig. 42 PATHS FOR NORTH COAST ANALYSIS

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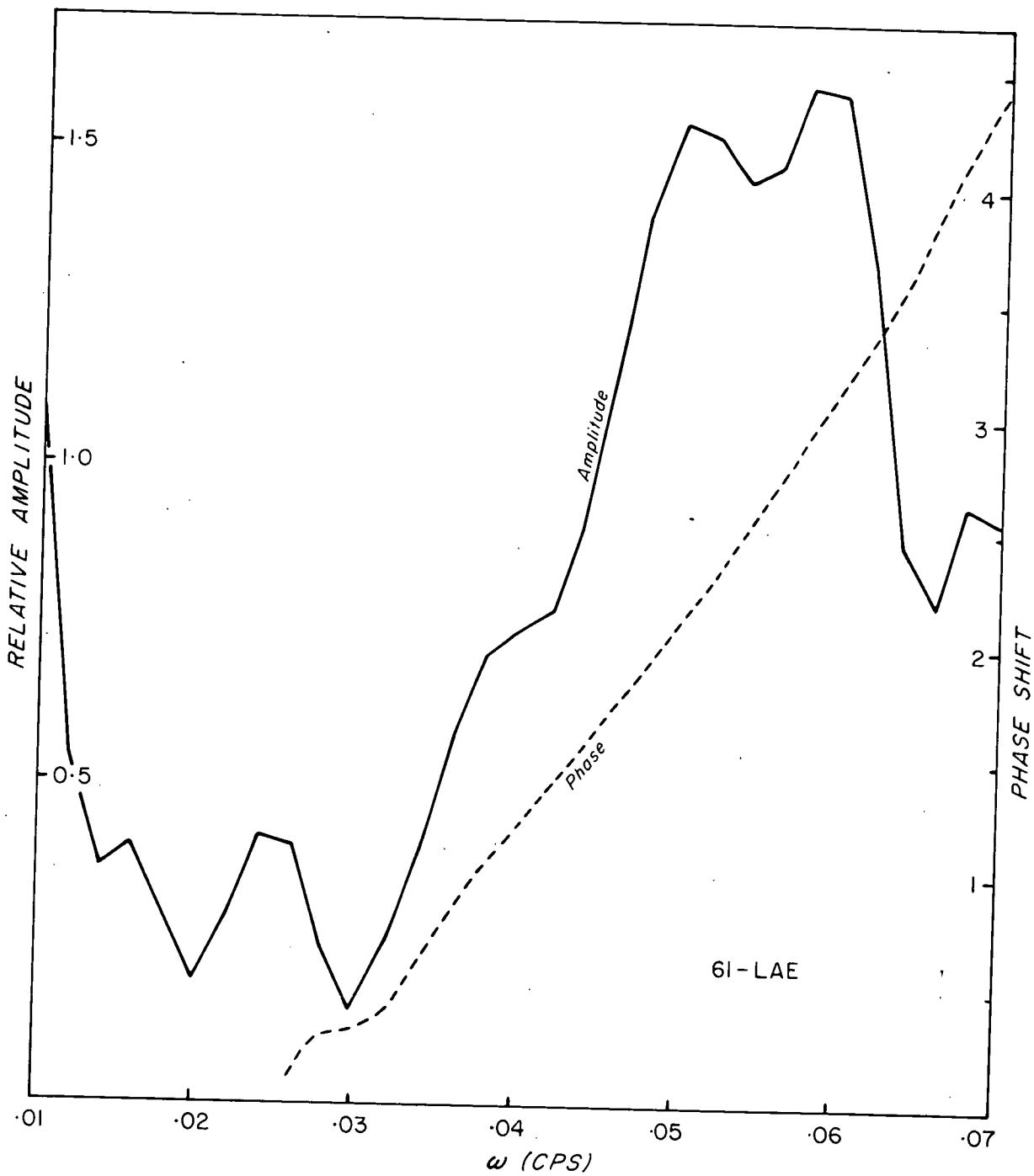

FIG. 43 SPECTRUM OF EVENT 61-LAE

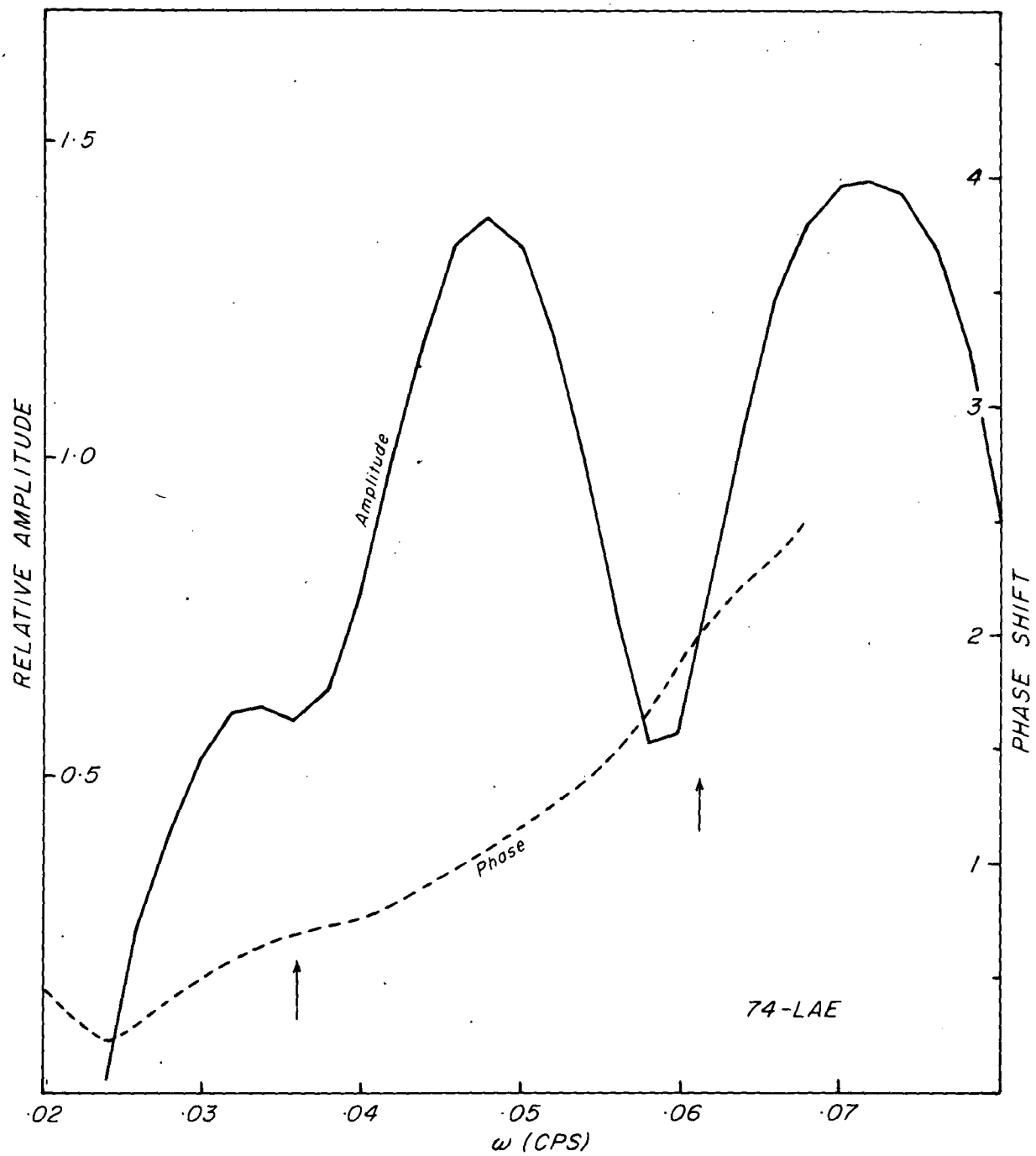

FIG.44 SPECTRUM OF EVENT 74-LAE, ILLUSTRATING INTERFERENCE EFFECTS ON PHASE SPECTRUM

6.2 OBSERVED DATA

Only four earthquakes, 61, 70, 71, 74, having wave paths confined to the region were available for analysis. Their positions together with part of the paths from two other events 67, 68 are shown in Fig. 42. Source and path data are listed in Table 14.

Event 71 was excluded because of recorder failure during passage of the wavetrain. Event 74 proved unreliable because of suspected interference effects. Figs. 43, 44 display the Rayleigh wave spectra from events 61, 74 respectively recorded at Lae. The phase spectrum for 74 shows irregularities not evident in Fig. 43.

6.3 PHASE VELOCITIES

Dispersion profiles are shown in Fig. 45. The quality of the data was too low to allow a confident identification of the correct profile. The profile labelled A in Fig. 45 was inverted and the resulting mantle shear velocity is regarded as a probable lower limit to the average beneath the region. Coefficients for profile A are given in Appendix VIII.

The epicentral distances of events 61 and 70 are, respectively, 453 and 1051 km. The individual profiles within the set computed from event 61 are thus separated by greater velocity increments than those for 70 and the region of closest coincidence between the profiles should be fairly clear. The best match was first selected (filled upright and inverted triangle symbols of Fig. 45) but neither profile extended to periods exceeding 36 sec., and both contain inflexions which indicate that some contamination existed in the wavetrains analysed.

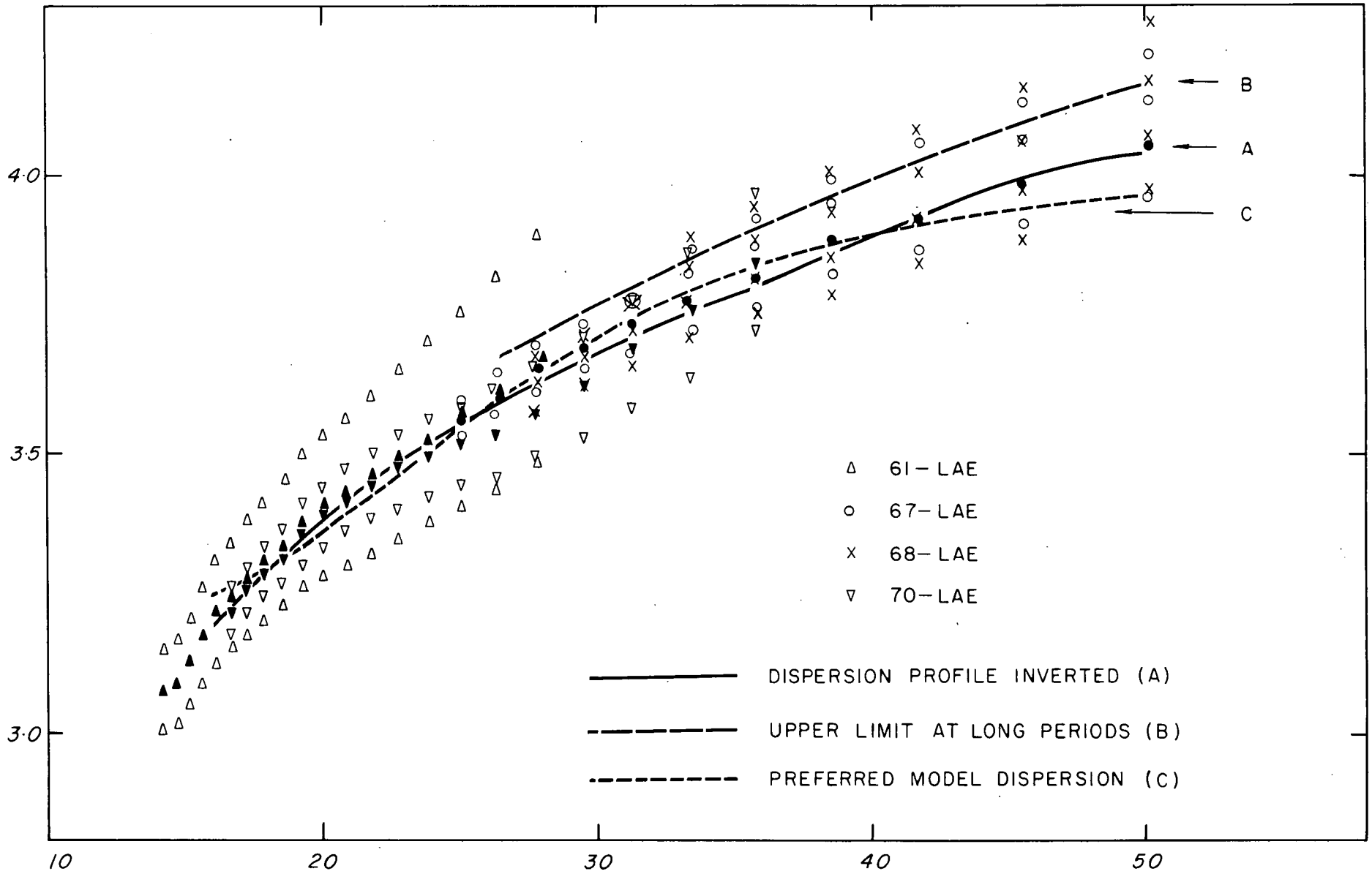

FIG. 45 ALTERNATIVE PHASE VELOCITY DISPERSION PROFILES CHARACTERING THE WAVEGUIDE BENEATH THE NORTH COASTAL REGION.

PNG/B9-28

TABLE 14

Earthquake Source Parameters

EVENT	ORIGIN G.M.T.	LAT °S	LONG °E	DEPTH KM	MAG C.G.S.	STATION	Δ (KM)	AZ (°)
61 9 Dec. 1966	14 54 43.3	4.1	143.7	63	5.2	LAE	453	128.8
67 1 Mar. 1967	14 24 26.5	-1.5	126.4	49	5.3	LAE	2436	111.9
68 3 Mar. 1967	08 52 48.8	-0.2	129.8	47	5.0	LAE	2017	111.0
70 27 Apr. 1967	08 09 47.9	1.8	138.7	33	5.3	LAE	1051	120.8
71 30 Apr. 1967	16 59 00.6	1.8	138.7	33	5.5	LAE	1051	120.8
74 21 May 1967	05 38 56	4.3	142.8	112	4.6	LAE	522	120.0

TABLE 15

Phase velocity data corresponding to profile A

T	C	T	C
50.0	4.047	32.0	3.725
48.0	4.028	30.0	3.680
46.0	4.000	28.0	3.632
44.0	3.968	26.0	3.580
42.0	3.931	24.0	3.523
40.0	3.893	22.0	3.457
38.0	3.852	20.0	3.381
36.0	3.811	18.0	3.291
34.0	3.768	16.0	3.184

TABLE 16

Parameters of the two layer model interpolated from solutions in Fig. 46. Velocities rounded to 1 decimal place

LAYER	Thickness km	α km/s	β km/s	ρ gr/cc
CRUST	37	6.2	3.4	2.8
MANTLE	-	8.0	4.5	3.32

The paths for events 67, 68 exceed 2000 km and traverse the cordilleran zone south of the region of interest here. However, it is reasonable to suppose that the mantle velocities below the M discontinuity and above 100 km, which control dispersion at long periods are not significantly different from those of the region north of these paths. Therefore, as an additional diagnostic, profile sets for these two events were added to Fig. 45. The best match between 67 and 68 also coincides with the matching profiles for events 61 and 70, and defines profile A. There is considerable ambiguity in selecting the long period data, and phase velocities up to 0.1 km/sec. above A may be equally representative. These are marked approximately by profile B.

Profile A is a 4th order polynomial fitting the four chosen observed profiles with a standard, least square, deviation of .021 km/sec.(Table 15). Profile B is hand sketched to enclose the adjacent, higher, sets of 67, 68. Sets above this, clearly separate in the reverse sense to those below A.

Inversion runs with 2 layer models were made for profile A using crustal thicknesses of 34, 36, 38 km. Solutions are displayed in Fig. 46. The solution most consistent with σ values in the range 0.25 to 0.30 was interpolated from these - Table 16 - and has a crustal thickness of 37 km. The dispersion for this model is shown as profile C.

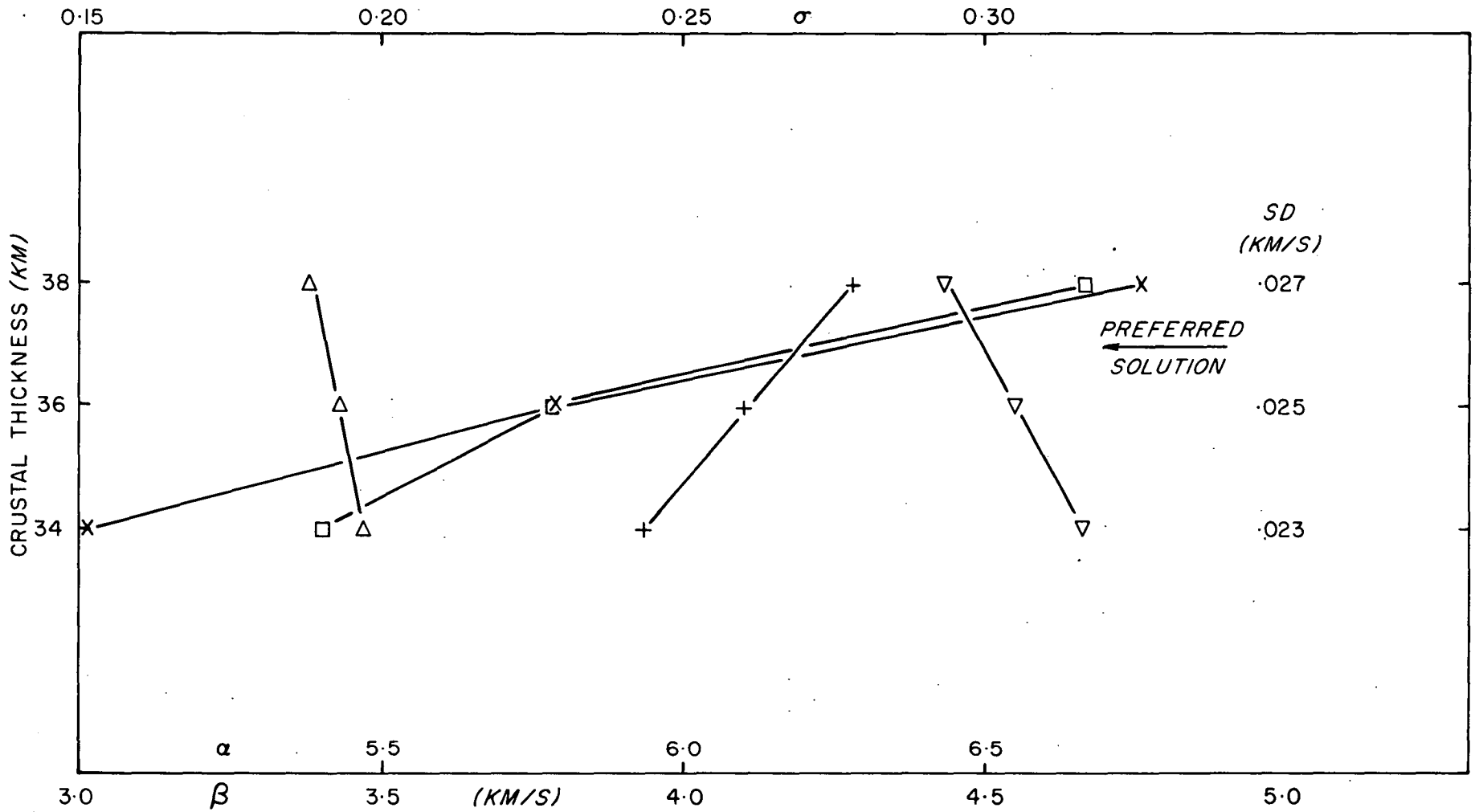

FIG. 46 INVERSION SOLUTIONS FOR PROFILE A

It is worth noting that the general shape of the phase velocity profiles in Fig. 45 is characteristic of a normal continental structure rather than one having a relatively thin crust for which the gradient dC/dT would be steeper. However it is also clear that while profiles A and C match in a least squares sense, the adopted 2 layer model may be too simple. A model having a more gradual increase in shear velocity with depth would allow more even distribution of smaller residuals throughout the profile. The quality of data and poor control over identification of the correct dispersion do not warrant a more complex interpretation.

An increase of mantle shear velocity to about 4.65 km/sec. would adjust the model dispersion to adequately match profile B. No significant change in crustal thickness would be warranted.

6.4 GROUP VELOCITIES

In Fig. 47 are shown group velocities computed by differentiation of polynomials fitted in a Chebyschev sense to phase velocity data for events 61, 67, 70. The irregularities in the phase velocity profiles are amplified in the group velocity curves which scatter to an excessive degree. No confirmation of the suitability or otherwise of the model group velocity profile is possible with these data, which do, however, indicate the necessity for group velocities to be available in the period range above 30 sec. to comprise a useful diagnostic.

6.5 CONCLUSIONS

The chosen model is a reasonable but fairly subjective interpretation of the available phase velocity data. It matches the interpretations of gravity data by St. John (1967) which suggested the existence of a crust

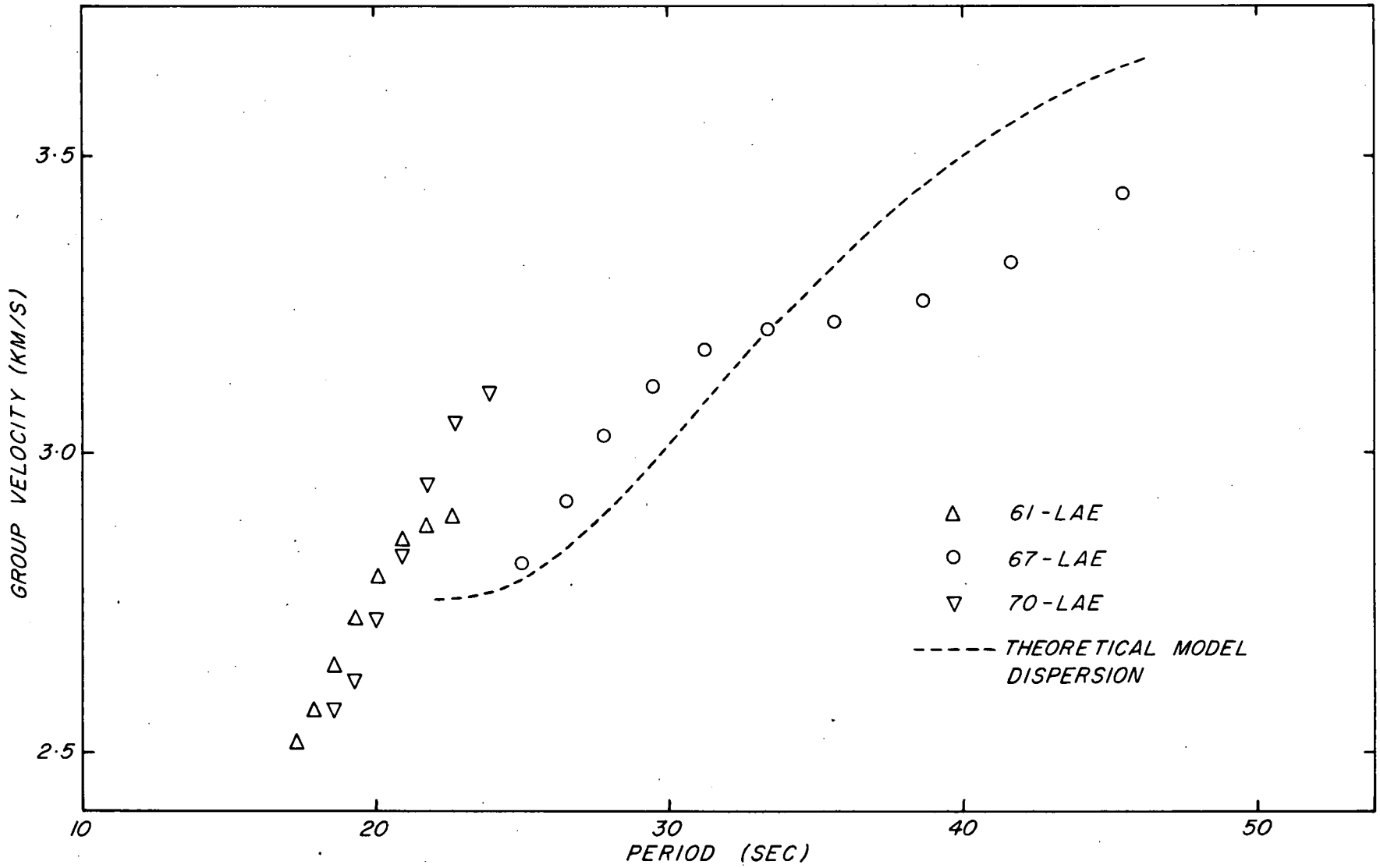

FIG. 47 DERIVED GROUP VELOCITY DISPERSION COMPARED WITH THEORETICAL DISPERSION FOR PREFERRED MODEL SOLUTION (TABLE 3)

of continental characteristics between the cordillera and the north coast of New Guinea.

Both Carey (1958) and Smith (1964) favour a taphrogenetic origin for the Mesozoic orthogeosyncline. A thickness of the order of 35 km is consistent with the subsequent orogenesis and formation of a root of low velocity material. The source of this root must have been the upper mantle.

7. THE CENTRAL CORDILLERA

7.1 GEOLOGY AND TECTONICS

The central New Guinea cordillera is an outstanding morphologic feature of the island. It is geologically separated from the Vogelkop but forms the main orography from there to the south eastern tip of Papua. Altitudes of 5000 m or so are common throughout the range which has a regional elevation exceeding 2000 m. This chapter is concerned with the part of the cordillera between longitudes 139°E and 146°E (Fig. 48).

The cordilleran axis primarily consists of two northfacing arcuate segments. The western arc comprises the Central Range of West Irian and the eastern arc incorporates the western, central and eastern highlands of New Guinea including the Victor-Emmanual, Bismarck and Owen Stanley Ranges.

There is no evidence of an early Palaeozoic orogeny, diastrophism beginning with mio-geosynclinal formation in the late Palaeozoic and early Mesozoic, marginal (north?) to the Australian craton. The Behrmann, Kubor and Bismarck massifs, marked respectively Be, K, Bm in Fig. 48, which comprise crystalline cores of the eastern segment of the cordillera are believed by Smith (1965) to have fractured from the pre-Permian platform as a result of the tensional deformation mechanism which he believes to be the basis of formation of the Papuan geosynclinal system. Radiogenic age determinations are needed to test this hypothesis, but none have yet been published. If of Palaeozoic age, these massifs remained as positive features during geosynclinal deposition, now represented by extensive regions of sedimentary sequences, notably the Nuku, Madang-Sarawuged-Finisterre, Southern Highlands and Lakekamu basins and the Wahgi and Aure troughs, marked 1 to 6 respectively in Fig. 48.

Alternatively these crystalline rocks may be a product of the main orogenic phase which began in the middle to late Tertiary, and

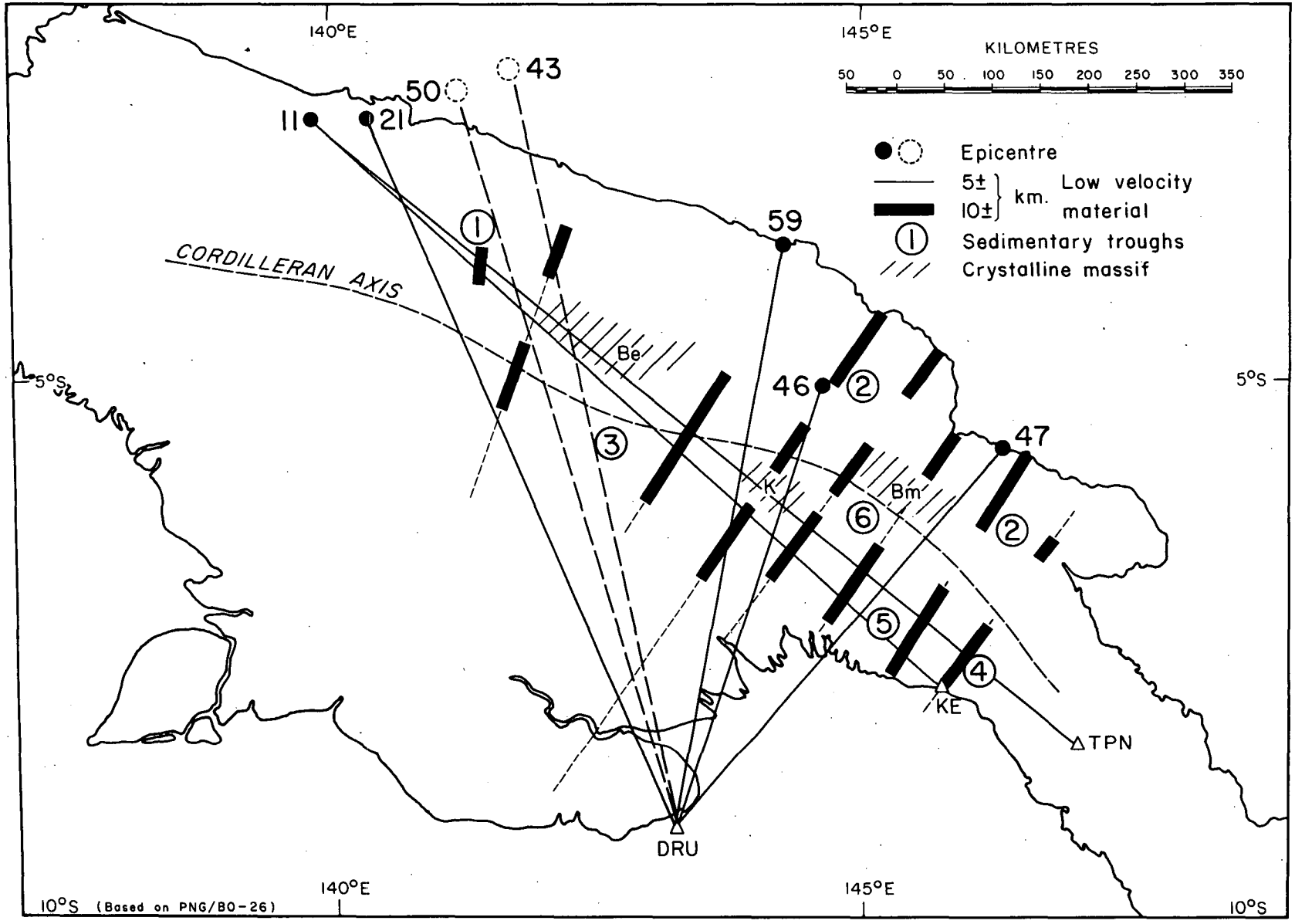

FIG 48 – EPICENTRES AND PATHS FOR CORDILLERAN STRUCTURE

PNG/89-67

was preceded by early Tertiary basic and ultrabasic magmatic activity in the northern part of the Central Range (Visser & Hermes, 1962).

The locations on Fig. 48, of low density rocks, have been culled from profiles and sections chosen by St. John (1967) for gravity analysis. Such low density and hence low velocity sequences, in places up to 10 km or so in thickness could influence the short period dispersion of Rayleigh waves which traverse them.

Adequate regional gravity data only exists throughout the region east of the West Irian border (141°E), (St. John, 1967). Visser and Hermes (1962) do show a Bouguer anomaly profile from the southern to northern coasts of West Irian but very sparse data indeed was actually observed across the Central Range, most detail being available for the northern and southern extremities of the profile. Regional negative Bouguer anomalies exceeding 100 mg characterise the central and western highlands, and the isostatic anomalies for these areas are of the order of -50 mg. St. John ascribes the large negative anomalies "to thickened sediments rather than an especially thick crust", and believes the central highlands region to be substantially compensated. This picture is consistent with the orogenic readjustment envisaged by Smith (1964) who believed the negative geosynclinal load to result in isostatic rise compensated by a rezoned upper mantle beneath the cordillera. In contrast to this, Visser and Hermes (1962, p.183) believe that the positive isostatic anomaly value indicates northward "overthrusting of the range and continental block", taken to be characteristic of the Central Range, quite contrary to the isostatic readjustment proposed by Smith for Eastern New Guinea. Their interpretation is probably premature in view of the gravity detail available, which was quite inadequate to define the extent and spatial frequencies of the isostatic anomalies involved or to correlate them with near surface geology, which, as St. John (1967) points out, can largely control such anomalies.

Evidence of some relative crustal thickening beneath the cordillera was provided by Brooks and Ripper (1966) who found lower group velocities for paths from epicentres in West Irian to Port Moresby which included parts of the cordillera, compared with those confined to the southern plains of New Guinea.

Brooks and Ripper also compiled P-wave travel time plots for 11 earthquakes in a general north westerly azimuth from Port Moresby, finding $P_n = 7.82 \pm 0.16$ km/s for the mantle and $P = 6.52 \pm 0.20$ km/s for the crust.

7.2 OBSERVED DATA

Epicentres and paths of the events used are mapped in Fig. 48. Epicentres of events 43, 50, suitably located but rejected because their phase spectra were perturbed, are also shown.

Source and path details are given in Table 17.

These data fall into two categories according to azimuth viz.

(a) Event 11 recorded at Kerema and Tapini with paths oriented to intersect the strike of the axis of the cordillera at an acute angle.

(b) Events 21, 46, 47, 59 for which paths traverse the cordillera at angles ranging from about 45 to 90°.

7.3 PHASE VELOCITIES

7.3.1 Event 11

Alternative sets of dispersion curves are shown in Fig. 49 and as before, correspond to increments of $\pm n\pi/2$ in ϕ_o. However, errors in ϕ_o will affect both profiles equally as only one source is involved. Five sets of profiles are shown, and standard deviations from 4th order polynomials

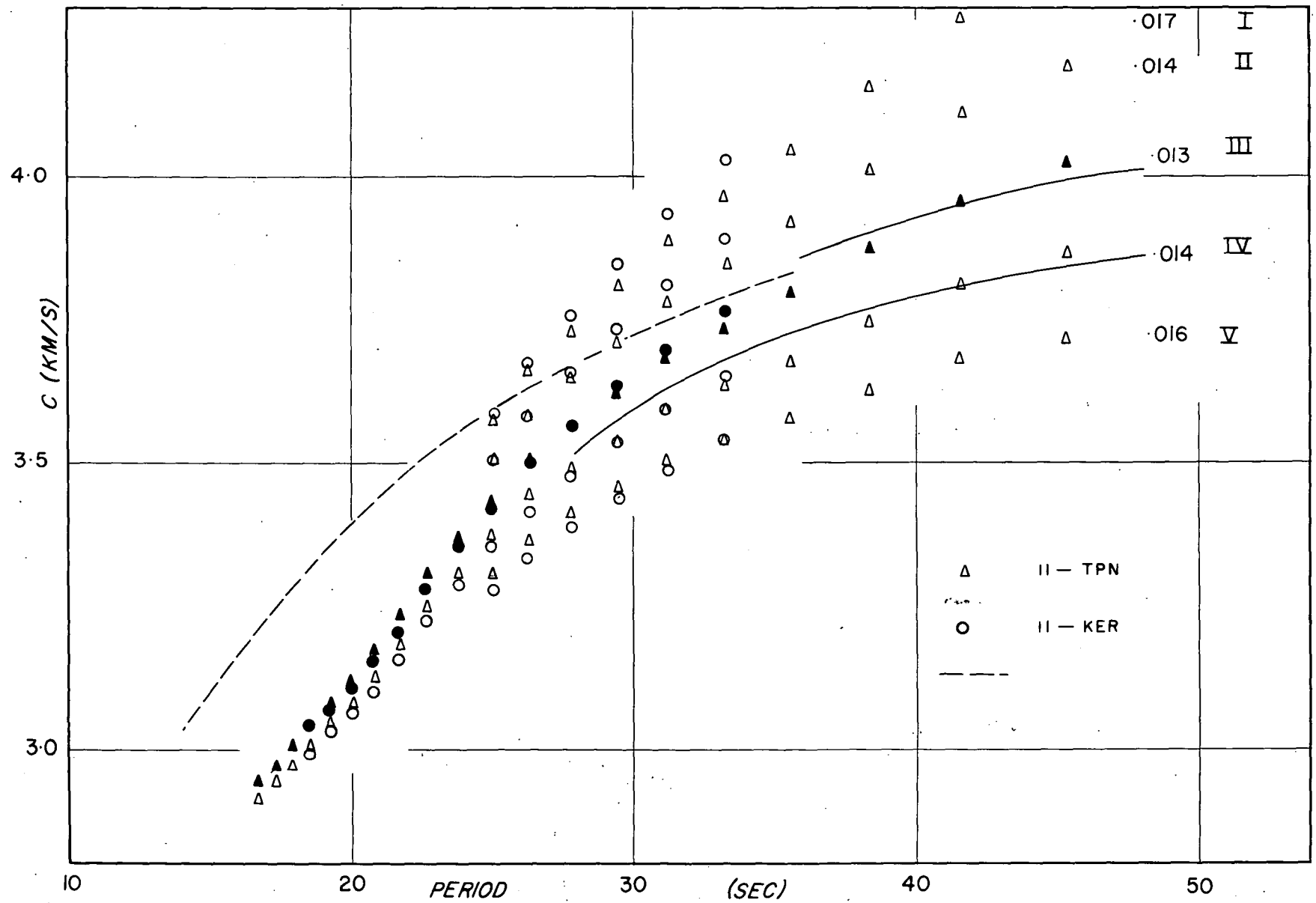

FIG 49. — DISPERSION SETS FOR EVENT II.

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indicated little difference between set III (S.D. = .013 km/s) and set IV (.014 km/s). See Appendix VIII for coefficients.

TABLE 17

Earthquake Source Parameters

EVENT	ORIGIN G.M.T.	LAT °S	LONG °E	DEPTH KM	MAG. USCGS	STATION	Δ (KM)	AZ (°)
11 18 Jan. 1966	20 19 25.6	2.6	138.8	54	5.5	KER	967	127.8
						TPN	1100	125.4
21 21 Mar. 1966	16 00 21.7	2.6	140.3	16	-	DRU	781	156.0
46 21 Jun. 1966	13 32 48.8	5.2	144.6	42	5.5	DRU	454	199.6
47 28 Jun. 1966	01 49 59.2	5.6	146.4	32	5.0	DRU	519	222.2
59 19 Sept. 1966	06 06 37.8	3.7	144.2	19	5.2	DRU	602	190.4

Both profiles were matched to two and three layer models. Approximate locations of low density crustal material have been marked on Fig. 48. These are taken from profiles drawn by St. John (1967, Fig. 4.6) which mark idealised geological cross sections drawn using regionally mapped geological data, and stratigraphic information from core holes, as control. The sections were modified to match the observed Bouger gravity anomalies. This evidence indicates that both paths included up to about 10 km or so of low density, and hence low velocity, material at the top of the crust. Representative parameters for such a layer, culled from St. John's descriptions, are

Thickness	α	β	ρ
km	km/s	km/s	gr/cc
10	4.5	2.6	2.6

Inversion runs for the two layer model, omitting this crustal layer, were made for crustal thicknesses of 32, 35, 38 km. Thicknesses of the lower crustal layer in the second set of inversions of a 3 layered model, incorporating the lower velocity layer, were 22, 25, 28 km. Reduction diagrams are not given but preferred solutions for both profiles are given in Table 18.

TABLE 18

Preferred solutions for event 11

	Thickness km	α km/s	β km/s	ρ gr/cc	σ	Profile Set
Two Layers	33	5.85	3.09	2.8	0.29	III
	-	8.30	4.63	3.32	0.27	
Three Layers	10	4.5	2.6	2.6	0.25	III
	25	5.89	3.34	2.8	0.26	
	-	8.0	4.75	3.32	0.23	
Two Layers	32	5.82	3.02	2.8	0.31	IV
	-	8.00	4.39	3.32	0.28	
Three Layers	10	4.5	2.6	2.6	0.25	IV
	23	5.95	3.25	2.8	0.27	
	-	8.0	4.5	3.32	0.27	

7.3.2 Events 21, 46, 47, 59

Phase velocities are shown in Fig. 50. The longest and shortest paths are those for 21 (781 km) and 46 (454 km) - see Table 17. Relative positions of corresponding profiles show that the match between the two central profiles is clearly superior to either of the surrounding alternative

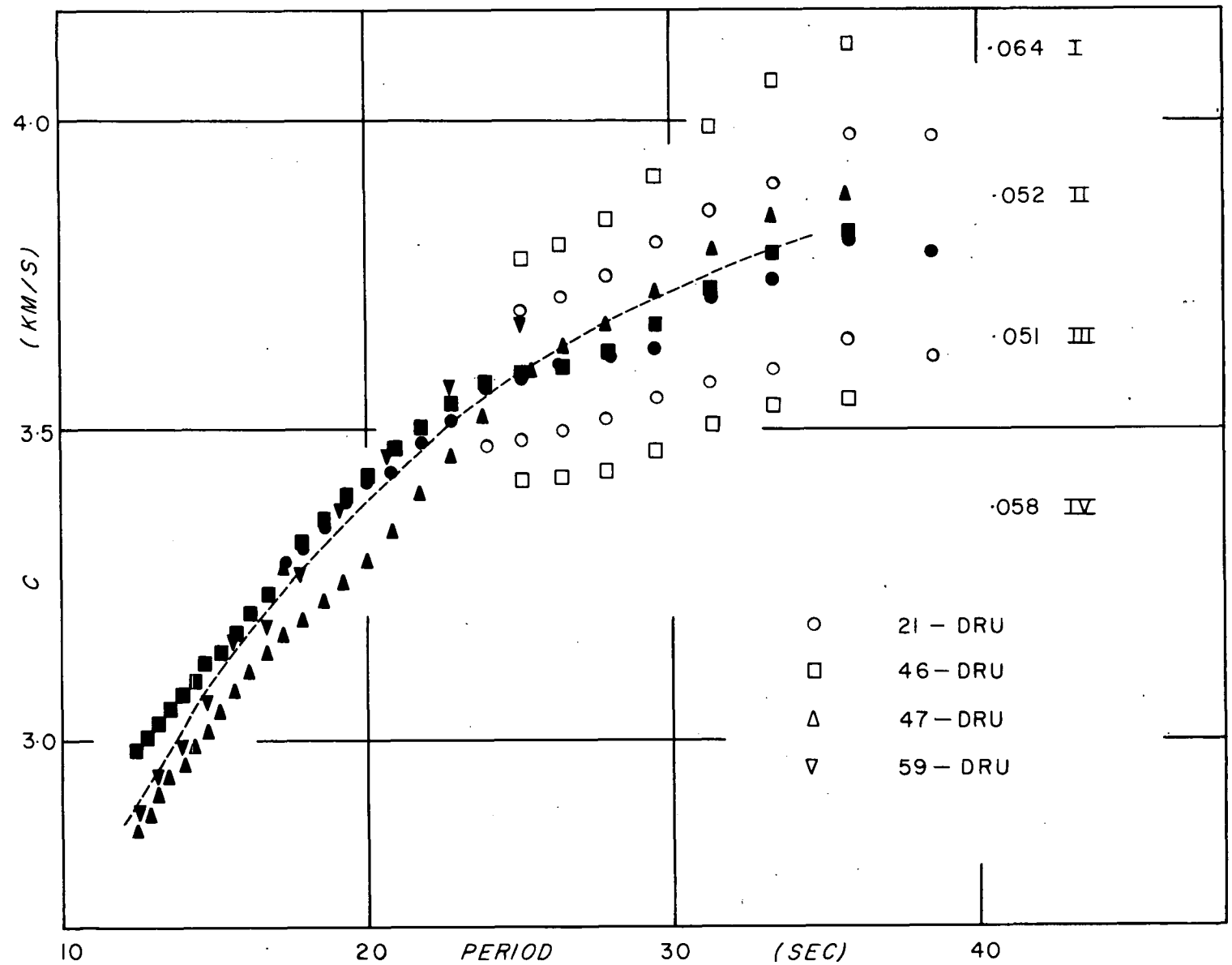

FIG. 50 DISPERSION FOR EVENTS 21,46,47,59.

sets. Only the profiles for events 47, 59 which best match this central pair have been added to Fig. 50 for the sake of clarity.

Standard deviations are marked in for four profiles and indicate a preference for the dispersion region surrounded by profiles II and III. Profiles III, IV from Fig. 49 and II, III from Fig. 50 therefore should define the dispersion region at long periods. These are shown in Fig. 51. Best agreement for periods exceeding 35 sec. is clearly between profile IV (Fig. 49) and profile II (Fig. 50). The standard deviation of a 4th order polynomial fitted to set II in Fig. 50 was .052 km/sec. Much of this scatter is caused by profile for 47 to Daru. Reference to Fig. 48 will show that about half of the path traversed the Gulf of Papua which, although not containing deep water in the area concerned, is underlain by a considerable thickness of sediments. A large segment of the remaining path is also underlain by low velocity material indicated in Fig. 48. These factors could explain the observed lower velocities at short periods associated with this profile.

The fitted polynomials were inverted in terms of a two layer model for crustal thicknesses of 28, 30, 32, 35, 38 km. The following preferred solution (Table 19) was chosen on the basis of a value for σ between .25 and .30.

TABLE 19

Preferred solution for Events 21, 46, 47, 59

h km	α km/s	β km/s	ρ gr/cc	σ
32	6.18	3.32	2.8	0.30
-	8.00	4.40	3.32	0.28

Model dispersion curves differed by less than the scatter in derived group velocities in the period ranges available. Longer periods are necessary to distinguish models on this basis.

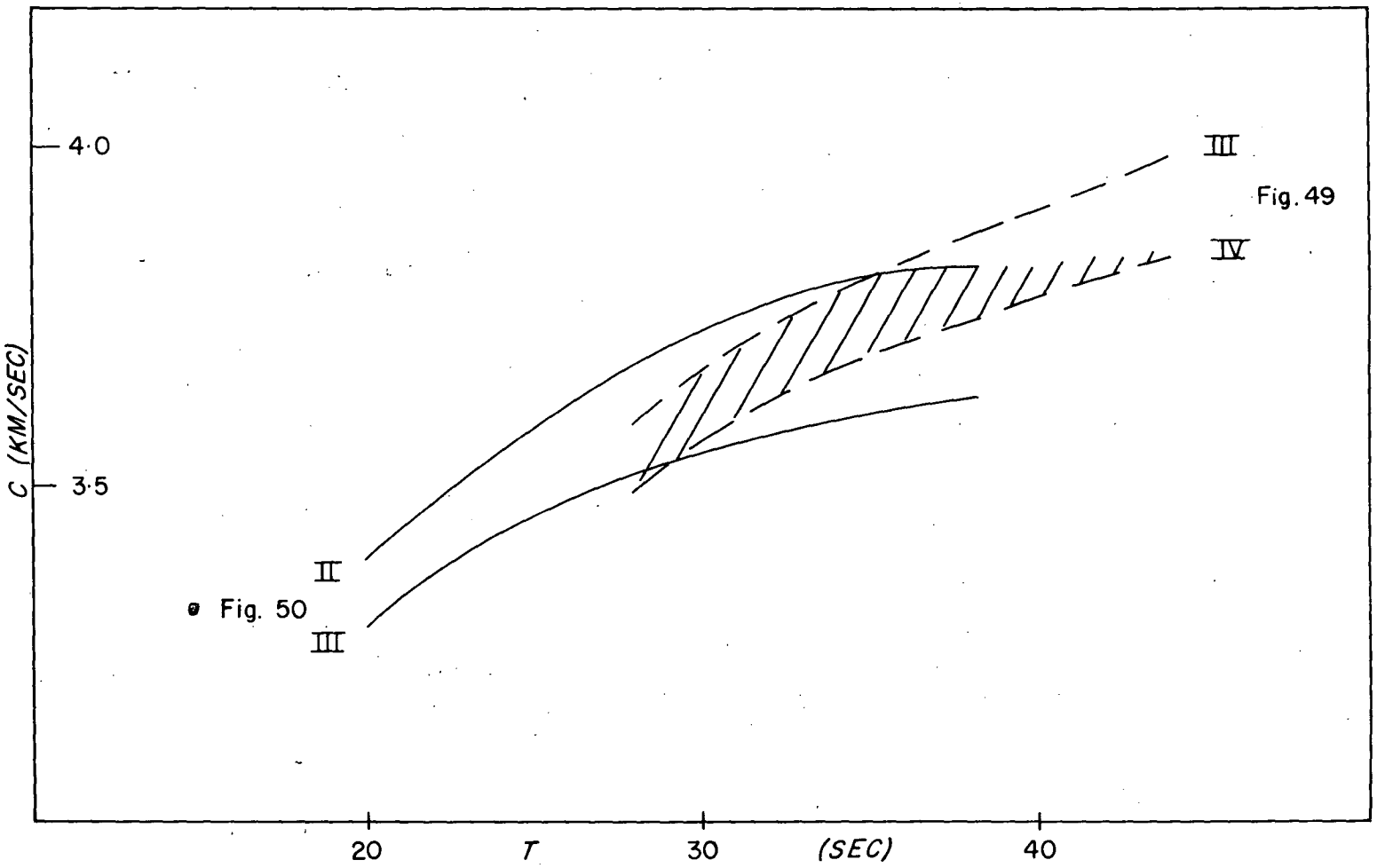

FIG. 51 — DISPERSION REGION COMMON TO PREFERRED PROFILES FOR PATHS STRIKING NW—SE (FIG 49), AND NORMAL TO CORDILLERA (FIG. 50)

PNG/89—70

7.4 CONCLUSION

The models in Table 18 (IV) and Table 19 give consistent upper mantle velocity characteristics of about 4.4 - 4.5 km/sec. The corresponding nominal α value used (8.0 km/sec.) gives a $\sigma \approx 0.27$. This agrees fairly well with 7.82 ± 0.16 found by Brooks and Ripper (1966) for the same general region.

Most of the paths studied here crossed portion of southern New Guinea and so the shear velocity for the upper mantle (4.4 - 4.5 km/sec.) are biased accordingly. Event 11, having paths with a smaller common southern New Guinea content would be influenced less than other paths and the higher shear velocities (4.6 - 4.7 km/sec.) for profile III Table 18, may represent an upper limit for the upper mantle beneath the Cordillera.

8. OWEN STANLEY RANGE

8.1 GEOLOGY AND TECTONICS

The tectonic evolution of the Owen Stanleys is believed to have followed similar lines to that of the Central Cordillera. The core of the range, of low to medium grade metamorphic rocks - the Owen Stanley Metamorphics - with acid intrusives of Miocene age (Davies, 1968), outcrops on the southwestern side of the Owen Stanley fault (Fig. 52). The fault is marked by a pronounced positive excursion in the Bouger anomaly profile from around zero south west of the fault to more than 100 m.g. on the ultramafic belt on the northeast side.

8.2 PHASE VELOCITIES

The dispersion curve for this region is defined by two-station data from events 7 and 14 to Port Moresby and Popondetta (Table 20).

TABLE 20

Earthquake Source Parameters

EVENT	ORIGIN G.M.T.	LAT (°S)	LONG (°E)	DEPTH (KM)	MAG. (C.G.S.)	STATION	Δ (KM)	AZ (°)
7 Sept. 3, 1965	21 38 53.6	5.2	153.7	54	-	POP	713	236.7
						PMG	854	236.8
14 July 27, 1965	15 53 44.1	6.8	155.1	86	5.5	POP	780	253.8
							916	251.2

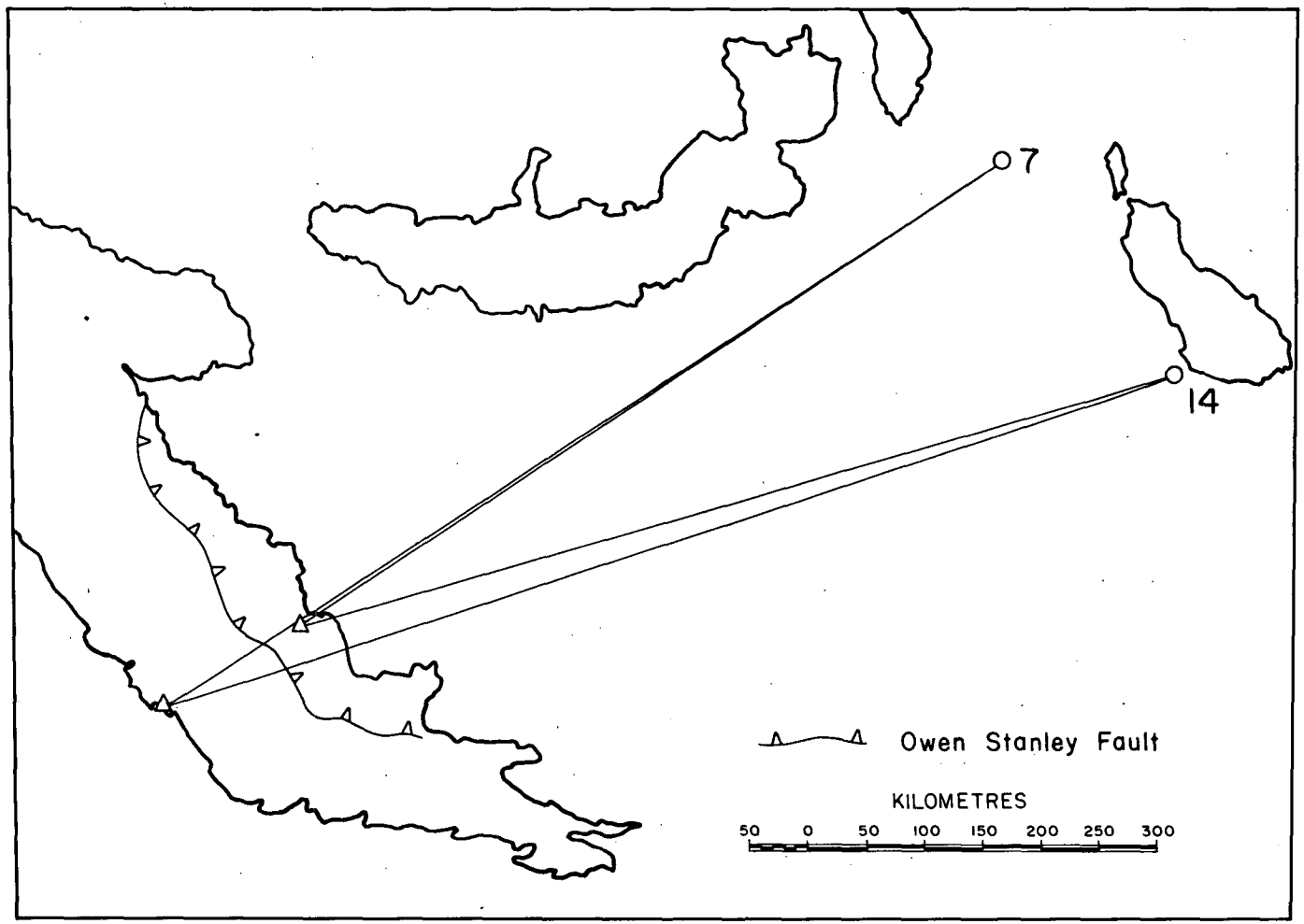

FIG. 52 SOURCES AND PATHS - OWEN STANLEY RANGES

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Event 7 should give more reliable results than event 14 as the source and both stations POP, PMG are almost colinear, and the paths are more nearly normal to the coast.

The interstation distance is about 140 km and travel times about 35 sec., requiring wave travel times to be consistent to within $\frac{1}{3}$ sec. to ensure an average departure of no more than about .04 km/sec. in the dispersion curve. Observed scatter exceeded this and some smoothing was necessary.

Chebyschev polynomials were fitted separately to each member of pairs of profiles $k(\omega)$ for 7POP, 7PMG and 14POP, 14PMG using a common value of ϕ_o for each pair. Travel times, recomputed from the smoothed curves were used to derive the two station dispersion curves shown in Fig. 53 a, b. The relative separations of single station profiles in these figures are not necessarily physically significant, being dependent on the initial phase, chosen for the illustration. This is only approximately correct. The paths for event 14, although differing in azimuth by less than 3^o intersect the bathymetric contours, north of the Papuan coastline, at a very acute angle which could introduce changes in travel time before the respective wavefronts reached the coast. The dispersion curve for event 7 is therefore regarded as more reliable profile for the Owen Stanley region, but only at long periods. In Appendix II it was shown that short period velocities, especially below 20-25 sec., for event 7-PMG were influenced by the short group velocity window used. Phase velocities are listed in Table 21.

This dispersion profile was not inverted in terms of a two layer model as the actual waveguide clearly does not approximate such a simple structure in view of the existence of the Owen Stanley fault. However it is reasonable to draw inferences as to the magnitude of the upper mantle shear velocity from the phase velocities at long periods. At 40 seconds, the wave motion penetrates well into the mantle and where structural heterogeneity of the kind introduced by the fault will be much reduced if not completely

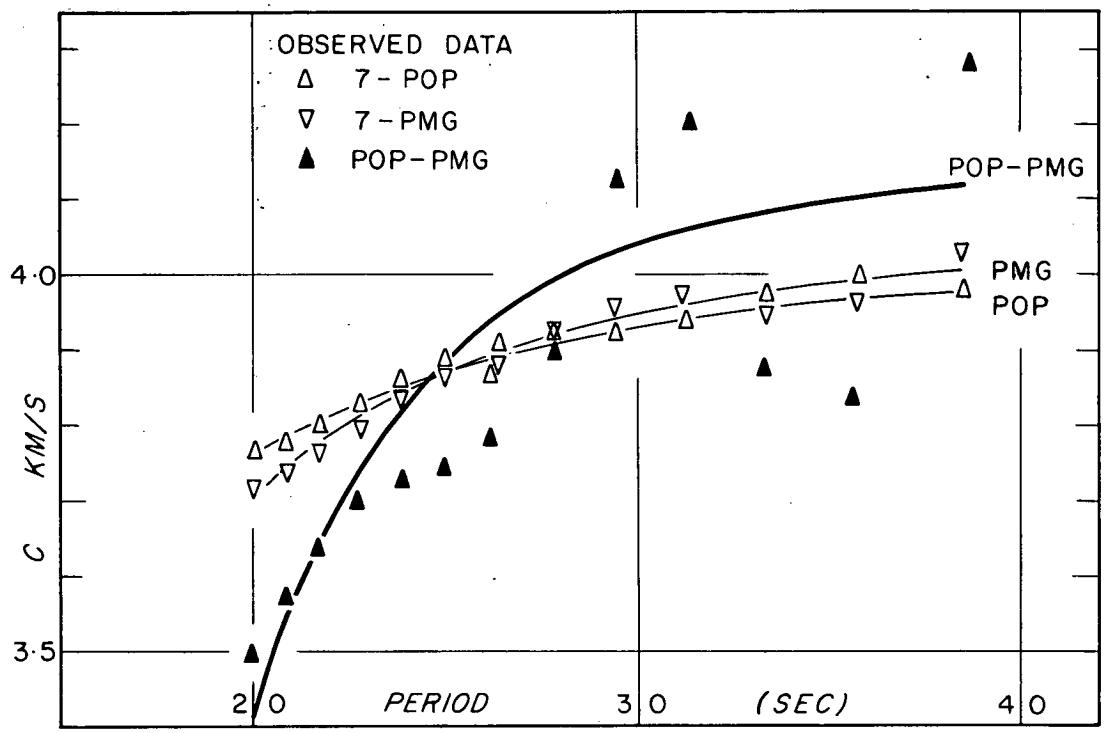

FIG. 53a TWO STATION DATA FOR EVENT 7.

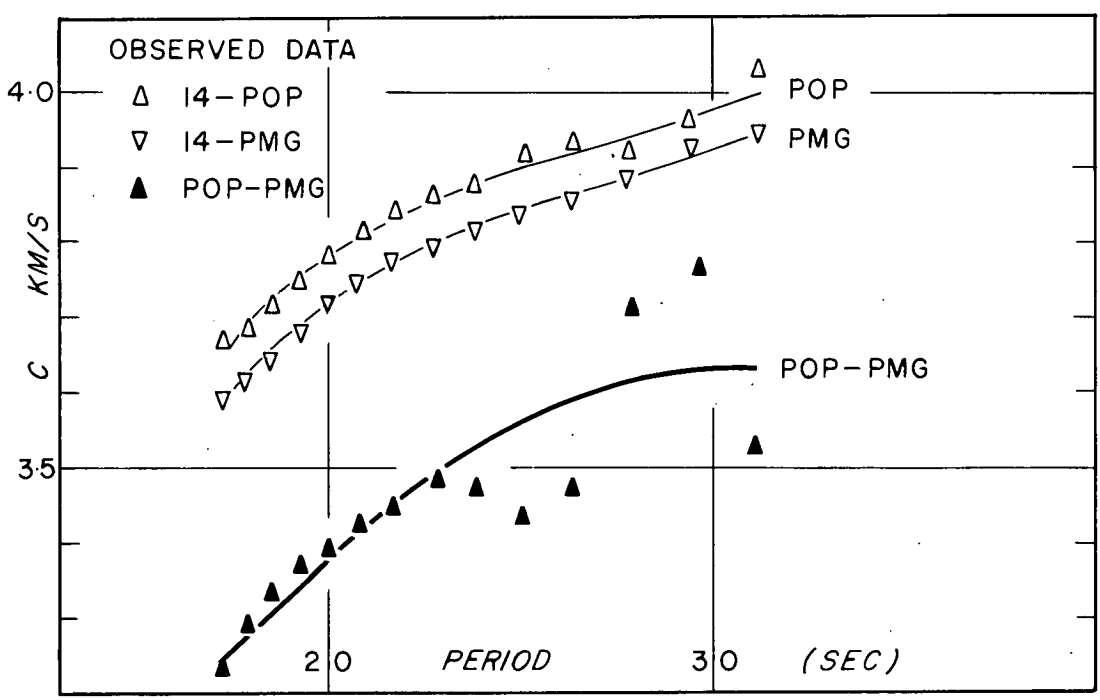

FIG. 53b TWO STATION DATA FOR EVENT 14. SOLID PROFILES ARE DERIVED FROM POLYNOMIALS FITTED TO OBSERVED SINGLE STATION DATA.

absent. Furthermore, the Owen Stanley fault is described as having low angle reverse characteristics, dipping towards the north (Davies, 1968; St. John, 1967) which would further minimise the upper mantle heterogeneity between Popondetta and Port Moresby in this depth range.

The important characteristic of the dispersion profile POP-PMG, Fig. 53a, is the phase velocity of about 4.1 km/sec. at 40 sec. period which indicates upper mantle shear velocities of about 4.6 km/sec. by comparison with a series of 2 layer model curves. This can be regarded as a maximum value. The phase velocity of 3.6-3.7 km/sec. deduced from event 14 is consistent with upper mantle velocities in the range 4.2-4.4 km/sec.

The upper mantle shear velocity, consequently, is believed to be above that for southern New Guinea, but below that for the Solomon Sea waveguide.

TABLE 21

Phase Velocities POP-PMG for event 7 (Fig. 53a)

T (Sec.)	C (km/sec.)	T (Sec.)	C (km/sec.)
38.46	4.118	25.00	3.861
35.71	4.098	23.81	3.819
33.33	4.079	22.73	3.737
31.25	4.058	21.74	3.645
29.41	4.028	20.83	3.543
27.78	3.991	20.00	3.434
26.32	3.941	-	-

9. REVIEW

This thesis provides new structural information relating to a complex region of the south west Pacific. The investigation was essentially a reconnaissance for shear velocities rather than compressional velocities, which are usually sought by refraction experiment. The choice of surface waves for the study was governed partly by the available economics and effort, but was not ideal. Both operational conditions and analytical problems were difficult.

Two positive results have emerged

(1) Some details of upper mantle structure beneath southern New Guinea

(2) Broad trends in the lateral variation of shear velocities in the upper 50 km of the mantle.

Upper mantle velocity profiles are often classified in terms of the general structural environment of the paths e.g. shield, oceanic or orogenic, (Toksoz and Anderson, 1966).

All three major structural types exist in New Guinea between 0 - 10°S and 135 - 155°E.

Upper mantle shear velocities are a characteristic of upper mantle mineralogy, in turn a product of the tectonic evolution of the region. It is therefore worth examining whether these shear velocity variations can be linked to processes involved in this evolution, in the context provided by specific tectonic hypotheses of the region, recent thinking concerning upper mantle mineralogical genesis and other geophysical data.

9.1 METHOD AND TECHNIQUE

I am not aware that phase velocity dispersion studies by others have employed single station data over such short paths as examined here.

Single station data is relied on exclusively for three regions, the Solomon Sea, New Britain and the North Coast region. Supplementary two station results are available for southern New Guinea and the Owen Stanley Range. "Common source" data are available for the Transcordilleran paths.

The most unsatisfactory aspect of using single station data arises from the unknown source phase and lack of precision of origin time and coordinates. Predictions, made in section 2.3.1, concerning the effect of the latter, have been consistently upheld throughout the analysis. The resulting phase velocity errors have been small enough to permit the use of increments of $\frac{\pi}{2}$ in a search for the correct region of dispersion for a particular waveguide.

The dispersion profile for southern New Guinea, defined at long periods from two station data, agrees with that defined by a minimum standard deviation from a group of single station profiles. For transcordilleran paths, the common source (event 11) and single station profiles converge at long periods as they should.

Higher modes were only available for the study of southern New Guinea and single station profiles were "locked in" to the fundamental mode data, confirmed from "two station" velocities, through a requirement that both sets should indicate a common value of shear velocity underlying the crust. Key features of the resulting upper mantle shear velocity profile agree with characteristics of the low velocity zone suggested by Brooks (1962) using a quite different approach (See Appendix V).

In the present study, a method was developed to establish a preferred layer thickness, for simple earth models by introducing an additional degree of freedom viz. Poisson's Ratio, σ, to the problem, to overcome a numerical difficulty. It provides a rational approach to an inversion problem otherwise limited by numerical circumstances.

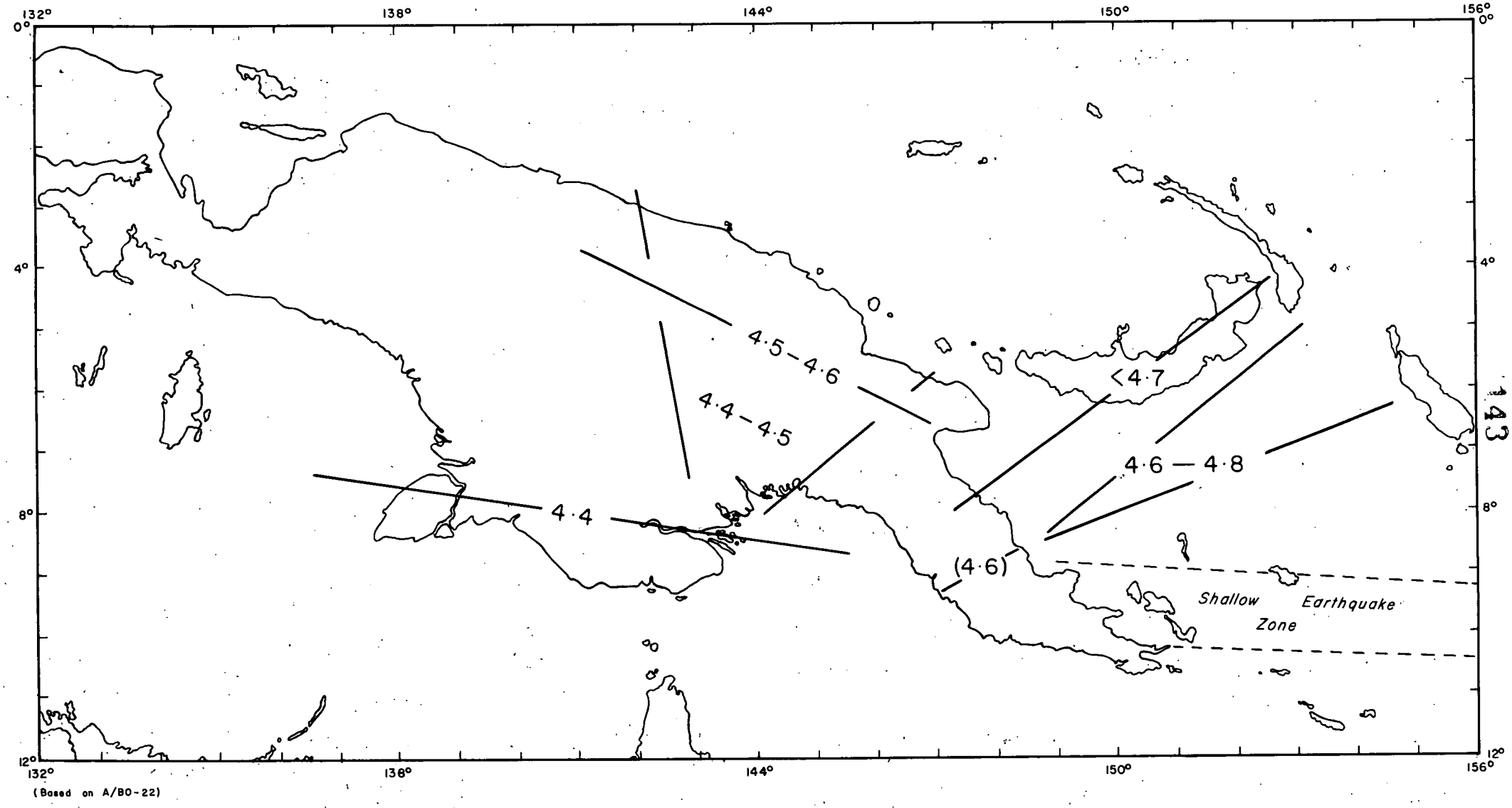

FIG. 54 VARIATION OF SHEAR VELOCITY IN THE UPPERMOST 50 km OF THE MANTLE.

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The precision of a model layer thickness determination is governed by the scatter in the data and the sensitivity of phase velocity to layer thickness

In the case of the simple models used in chapters 3 and 4, $\partial C/\partial h \approx .02$ km/sec.km, and scatter in the data, measured by the standard deviation was $\Delta C \approx .02$ km/sec. Thus the precision available is roughly given by $\Delta C/(\partial C/\partial h) \approx 1$ km, a figure consistent with that obtained by employing σ as a criterion.

By comparison, expected precision of shear velocities is of the order of .05 km/sec. for a particular reduction.

The above approach is an approximation of Berry & Knopoff's (1967) definition of precision, which minimised this quantity over the periods range concerned.

i.e. error = $\Delta C \sum_{i=1}^{m} \frac{\partial C}{\partial h}(T_i) \Big/ \sum_{i=1}^{m} \left[\frac{\partial C}{\partial h}(T_i)\right]^2$ for m values of period.

Page 144, line 17: for "Principle" read "Principal".

9.2 RESULTS

Principle results of the study are summarised in Table 22.

Fig. 54 illustrates the regional changes of upper mantle shear velocity found. Velocities are lowest beneath the crust of southern New Guinea, 4.4 km/sec. and highest, 4.7 ± 0.1 km/sec., beneath the crust of the Solomon Sea region.

The remaining, orogenic zones, are underlain by material having velocities between these extremes.

Crustal thickness values are most significant where the waveguide is laterally uniform. Only in southern New Guinea is this probably so, and the average value of 33 km is the first direct interpretation of crustal dimensions of the region. Elsewhere, for example below the Solomon Sea,

the thickness of the crust varies considerably throughout. The model thickness will be intermediate between extreme values along the path but not necessarily an arithmetic mean.

TABLE 22

Principal Results

REGION	"Average" Crustal Thickness km	Upper Mantle Shear Velocity km/sec.
Southern New Guinea	33 ± 1	4.4
Solomon Sea	17 - 22	4.6 - 4.8
North Coast	37	4.5 - 4.6
Central Cordillera	(33)	4.4 - 4.5
Owen Stanley Range	?	(4.6)

If the waveguide is subdivided lengthwise into segments, provided secondary interference effects produced at segment boundaries are neglected, phase velocity across each segment is dependent not only on thickness but also will be governed more by variations in velocity, both in the crust, and the upper mantle, along the waveguide. The latter velocity will probably be more uniform than the former as the waveguide approaches homogeneity with increasing depth.

9.3 INTERPRETATION

Shear velocities are a function of composition, temperature and pressure, and these in turn are related to the tectonic history of the region in question.

In this section I wish to draw together both general and specific hypotheses relating to the origin of New Guinea and discuss the upper mantle shear velocities, found in the current study, in this context.

9.3.1 The Upper Mantle

Ringwood (1969) believes that four basic processes operate to affect upper mantle composition.

(a) Changes in position of the regional geotherm on the temperature:pressure "plane".

(b) Mineralogical zoning, i.e. the potential of a primary material to form different stable mineral assemblages under different conditions of temperature and pressure.

(c) Chemical zoning, i.e. fractionation of low-melting components, from a given mineral assemblage, under environmental control.

(d) Partial melting, which occurs as the temperature, pressure environment nears the solidus. Ringwood (loc. cit.) distinguishes partial melting (5 - 30%) from incipient melting ($\sim$ 1%).

Temperature and pressure exert contrasting influences on velocity. Anderson et al (1968) have published data on the velocity dependence of various minerals on temperature and pressure. Those minerals likely to comprise significant components in the upper mantle i.e. olivine, pyroxene, garnet, spinel, and both magnesium and aluminium oxide have the following temperature and pressure derivative ranges

$$-.0005 \lesssim \left(\frac{\partial \beta}{\partial T}\right)_P \lesssim -.0002 \text{ km sec.}^{-1} (^{\circ}C)^{-1}$$

$$+.002 \lesssim \left(\frac{\partial \beta}{\partial P}\right)_T \lesssim .005 \text{ km sec.}^{-1} \text{ kb}^{-1}$$

The exception is spinel for which $\left(\frac{\partial \beta}{\partial P}\right)_T \approx .0004$, and which forms a minor component in some assemblages considered by Ringwood (1968). On the above basis, temperature differences between 200 and 500°C or pressures of 20 to 50 kb are necessary for a $\Delta V_s \approx 0.1$ km/sec. differential.

The shear velocity difference between the southern New Guinea upper mantle and that beneath the Solomon Sea is about 0.3 km/sec. Allowing for a 15 km (5 kb) pressure difference at the M discontinuity, the geotherm beneath the Solomon Sea should give lower temperatures by about 1000°C to account for the difference without change in mineralogy.

The approximate positions of regional geotherms considered by Green and Ringwood (1967) suggest little difference in temperature between a depth corresponding to 7 kb under the oceans and that corresponding to 10 kb beneath shield structures.

One effect of partial melting is discussed below, but the environment is unlikely to approach the solidus at shallow depths i.e. between the crust and say, 50 km, except in active volcanic zones which are much smaller in dimension than the regions considered here and I am therefore inclined to exclude this effect as a cause of a shear velocity disparity in this depth range. Ringwood (1969) argues strongly that water content exercises a stabilising influence on any tendency for partial melting to occur, except in these regions.

Thus one must look to mineralogical stability fields and chemical zoning factors to account for regional velocity changes in New Guinea.

9.3.2 Tectonic Hypotheses

(a) Tectonic History of New Guinea

The post Palaeozoic orogenesis and geotectonic development, culled from the work of Smith (1965) and Carey (1939, 1958) might be summarised as follows.

(i) An initial taphrogenetic phase during which an orthogeosynclinal trough began to form, marginal to the Australian craton, in the Jurassic, continuing into Cretaceous time.

(ii) A Palaeogene stabilisation phase. During this time, upper mantle temperatures beneath the geosyncline would rise, perhaps allowing fractionation of lower melting point components of the upper mantle.

(iii) Commencement of a regional anticlockwise rotation indicated by the palaeomagnetic data, (Manwaring, pers. comm.) possibly coincided with the retrogressive taphrogenetic phase placed by Smith (1965) in the Lower Miocene. Carey (1939, 1958) believes, on structural geological evidence on a local, regional and continental scale in the reality of such anticlockwise rotation.

(iv) The possibility that rotation of New Britain continued by up to 90°, according to provisional Palaeomagnetic interpretations by Manwaring (pers. comm) may explain formation of the Solomon Sea.

(v) A Plio-Pleistocene orogenic phase accounting for the main orographic features of present day New Guinea.

If such movements of "continental drift" really occur, it is important to consider the depth at which shearing or viscous flow occurs.

(b) Continental Drift

Anderson (1962) discussing the nature of the upper mantle said "Almost all present theories of . . . drifting of continents focus attention on the Mohorovicic discontinuity . . . the important discontinuity is farther down, at the ill defined boundary of the rigid lithosphere and weaker asthenosphere . . . the existence of such a plastic layer makes the idea of continental drift plausible".

Other seismologists considered the effect of a thin plastic layer on dispersion e.g. Harkrider, Hales and Press (1963).

More recently Anderson & Sammis (1968) considered the influence of partial melting at the top of the low velocity zone as a result of a lowered solidus temperature, caused by a high water pressure.

Hales (1961) discussed the possibility of a weak layer in the low velocity zone of the mantle and more recently (Hales, 1969) postulated a diagrammatic concept of lateral gravity assisted movement along such a viscous layer at depths down to about 100 km.

(c) Continental and Oceanic Evolution

The arguments of Bullard (1952) and Rubey (1955) have been applied by Clarke and Ringwood (1964) and Ringwood (1966) to support the contention that the crust is a low melting point differentiate of a more primitive material viz. pyrolite, of which the upper mantle is composed, at depth. On this hypothesis, the continents are believed to have developed in a general way from primitive oceanic basins throughout geological history.

Ringwood (1969) listed velocities (at atmospheric pressure) for the various assemblages of pyrolitic composition. These suggested that the residual refractory dunite has a higher velocity than other assemblages. Examination of the equilibrium diagram for the forsterite-fayalite system, as shown for example by Roedder (1959), discloses that following a loss of low melting point components, the residual material becomes richer in forsterite which has a lower density and atomic weight, but a higher compressional wave velocity than fayalite (Birch, 1961).

Thus a residual refractory upper mantle material beneath the continents is expected to exhibit higher shear velocities than beneath the more primitive, in the evolutionary sense, oceanic crust, in otherwise equivalent circumstances.

An apparent contradiction occurs in New Guinea where a reverse trend in velocities exists.

Wiebenga et al (in prep.) have discussed results of some refraction profiles in the region of northern New Britain from which a strong correlation between sub crustal and lower crustal compressional velocities is suggested. They infer the operation of a vertical fractionation process.

The upper mantle velocities beneath continental and shield regions which are more highly evolved than oceanic regions, are probably influenced to greater depths by processes of fractionation. Velocities "are controlled by a number of factors which probably vary widely in their relative importance in different regions of the earth". Although Ringwood (1969) was referring specifically to the low velocity zone, this comment applies more generally. Altogether, too little is yet known to make worthwhile suggestions as to the causes of the observed lateral variations of shear velocity shown in Fig. 54.

9.3.3 Regional Implications

(a) Southern New Guinea

The upper mantle beneath this region has a comparatively low shear wave velocity of about 4.4 km/sec. Previous discussion of the geological setting of this region, in section 3.1, characterised it as having shield structure characteristics.

The shear velocity profile in Fig. 22 displays a thick lid capping the low velocity zone similar to the CANSD profile, but velocities are significantly less than the CANSD model for the whole profile. Everingham (1965) has also found high velocities ($P_n \approx 8.5$ km/sec.) beneath the ancient Australian shield.

Lower upper-mantle velocities in the southern New Guinea region may be simply a result of different primary composition. In addition, an important parameter needed in this discussion to compare southern New Guinea with the older shield regions, is heat flow. While some data are available

for Western Australia, no measurements have been reported from southern New Guinea. Proximity of the region to active orogenic and volcanic zones implies a probably higher heat flow than otherwise. The existence of low velocity zones for shear waves and probably also compressional waves lends further support to this implication. Anderson and Sammis (1968), using, inter alia, the data of Brooks (1962) concluded that low velocity zone profiles of the type found in the present study could not be explained solely in terms of high temperature gradients and found it necessary to invoke partial melting as an additional factor. One significant finding by Anderson and Sammis (1968) was that "pronounced low-velocity zones are incompatible with regions of normal heat flow". The heat flow values for both Canadian and Western Australian shield areas given by Lee and Uyeda (1965), pp. 100, 106, are about 1 μcal/cm^2. Khan and Woollard (1968) reported the associations of high heat flow values with low upper mantle velocities in the Solomon Islands Region.

(b) Solomon Sea

Any consideration of the origin of new oceanic basins such as the Solomon Sea must recognise the significance of recent theories of sea floor spreading arising from observations of magnetic anomalies over ocean ridges (Vine and Mathews, 1963). Subsequent work, for example by Sykes (1966) and Isacks et al (1968), has placed considerable emphasis on the seismicity beneath deep oceanic trenches, which are now widely postulated as marking zones of sinking sub-crustal material. Ringwood (1969), following Green & Ringwood (1967) and Hess (1962) has proposed a hypothetical model of the ocean floor spreading concept from ocean ridge to trench.

There are two ocean trenches in the Solomon Sea, adjacent and striking approximately at right angles. It is difficult to conceive a mechanism of ocean floor development in which both trenches are "sinks" of the kind postulated above. No clearly established ridge having the

characteristics needed to support this hypothesis is known yet. The seismicity studies by Brooks (1965) and Denham (1969) reveal a poorly defined zone of shallow earthquakes between the eastern tip of New Guinea and Guadalcanal which might justify further investigation, as a possible remnant (or embryonic) ridge structure. See Fig. 54.

If differential anticlockwise movement occurred between New Britain and New Guinea, the greatest relative lateral motion occurred much deeper than the M discontinuity.

In Chapter 5 the convergence of group velocity dispersion profiles for paths crossing New Britain and excluding New Britain led to the conclusion that shear velocities below about 80 km were probably about the same beneath the Solomon Sea and New Britain. This finding is consistent with the discussion 9.3.2 (b).

The average upper mantle shear velocities of 4.6 to 4.8 km/sec. for this region are quite consistent with the range of compressional velocities given by Ringwood (1969) for the mineralogical compositions believed by him to compose the oceanic upper mantle.. Moreover they are also within the range of shear velocities corresponding to compressional velocities of 8.0 to 8.6 km/sec. found by Raitt et al (1969) to be directionally dependent in their study of anisotropic characteristics of the northeast Pacific Ocean.

Another factor to be remembered in any discussion of this region is the structural geology of the Papuan Ultramafic Belt, supposed to be a low angle overthrust feature from the north-east, but I cannot at present reconcile this postulate with the little evidence so far known about the origin of the Solomon Sea basin.

(c) Orogenic Regions

Lengthy comment on upper mantle velocities beneath the central cordillera and the north coastal region is not justified. The data are not significantly different to velocities beneath southern New Guinea and

it is impossible to distinguish the relative influence on the shear velocities of

(i) formation and segregation from the upper mantle of a root of low density rocks beneath the cordillera. Acting alone, such a process would tend to leave a residual mantle material of relatively higher velocity.

(ii) high temperature gradients conomitant with late Tertiary to Recent orogenesis.

(iii) possible differences in the primary mantle material beneath the southern margin and the depositional basin of the Mesozoic geosyncline.

9.4 CONCLUSIONS

At the present stage of knowledge of crustal and upper mantle geophysical parameters in New Guinea, I believe these data simply provide a small addition to existing results of other investigations already mentioned.

The variables which affect velocities in such a complex region may have such a pronounced influence that much more investigation is needed to separate the factors such as anisotropy, mineralogical zoning and temperature. Such work will need to be very detailed.

Too little is known to assess the importance or otherwise of sea floor spreading in the formation of the Solomon Sea, and the tectonic interpretation to be placed on the seismicity of the region. While the data discussed by Denham (1969) is of high quality, his interpretation of the seismicity beneath the trenches bordering the Solomon Sea as the manifestation of the "leading edge" of the "the northward-moving Australian 'plate'" seems a little premature. His further interpretation of the seismicity

beneath New Guinea itself as being a consequence of "an overthrust zone of mountain building" cannot easily be reconciled with the more established and better documented interpretations of Smith (1964), St. John (1967) and their predecessors, who laid considerable emphasis on evidence pointing to uplift of the Papuan geosynclinal zone.

Heat flow measurements in the area would provide a most valuable criterion for interpretation.

Finally, as I have previously remarked, the use of surface waves in such a region cannot be recommended except to analyse uniform waveguides such as southern New Guinea, or to provide information about the upper mantle well below the crust where the waveguide is more uniform than at shallow depths. A study of higher mode dispersion from some of the deeper earthquakes could yield valid data on the velocity "structure" of short paths of similar length to those employed here.

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In 1965, before I moved to Hobart, Dr. James Dorman of the Lamont-Doherty Geological Observatory provided me with copies of his Fortran IV programs PV7EF and INV3 for evaluation of dispersion and model inversion problems. Although translated into Algol and subsequently modified during the course of this work, the programs remained the basis for corresponding calculations throughout the study.

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APPENDIX I

SURFACE WAVE ANALYSIS

(a) Numerical Fourier Analysis

The seismogram, $f(t)$, recorded at distance r from the source, is available for phase velocity analysis. In practice $f(t)$ is selected over a specified time interval beginning at t_1 seconds after the disturbance originates at the source.

The Fourier spectrum of $f(t)$, computed by taking the zero of time at the origin time plus t_1 seconds, is $F(\omega) = S.G.R.$ where S, G and R are the following complex functions:

$S \equiv |S(\omega)| e^{i\phi_o(\omega)}$, the source function

$G \equiv |A(\omega)| e^{-\alpha(\omega)r} \cdot e^{-ik(\omega)r}$, the ground transfer function which includes α, an attenuation factor and $k = \omega/C(\omega)$, C being the phase velocity to be found.

$R \equiv |R(\omega)| e^{i\phi(\omega)}$, the receiver (seismograph) transfer function.

Thus $F(\omega) = |F(\omega)| e^{i\theta}$, where $\theta = -kr + \phi_o + \phi$ . . . . . (1)

and $f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} |F(\omega)| e^{i(\omega t+\theta)} \, d\omega$ . . . . . (2)

We now wish to examine the time function $f_1(t)$ corresponding to a particular frequency ω_1 of this spectrum.

i.e. $f_1(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} |F(\omega)| e^{i(\omega t+\theta)} \cdot \delta(\omega-\omega_1) \, d\omega = |F(\omega_1)| e^{i(\omega_1 t+\theta)}$ . . . (3)

where $\delta(\omega)$ is the delta function or impulse symbol, and $|F(\omega_1)|$ contains the normalising factor $\frac{1}{2\pi}$.

The component of the seismogram corresponding to $f_1(t)$ is

$$Re\{f_1(t)\} = Re\,|F(\omega_1)|\,e^{i(\omega_1 t+\theta)} = |F(\omega_1)|\cos(\omega_1 t+\theta)$$

Thus the phase angle for frequency ω_1, emerging from a Fourier analysis of $f(t)$ is $\theta = -\omega_1 t$ and the time delay, relative to t_1, to the peak of the wave, is $t = -\frac{\theta}{\omega_1}$

Hence the "phase travel time" from the origin, measured on the seismogram, is $t = t_1 - \frac{\theta}{\omega_1}$

and the "phase travel time" through the ground

$$\frac{r}{C(\omega_1)} = t_1 - \frac{\theta}{\omega_1} + \frac{\phi_0}{\omega_1} + \frac{\phi}{\omega_1}$$

thus $$C(\omega_1) = r\omega_1/(\omega_1 t_1 - \theta + \phi_0 + \phi) \qquad \ldots\ldots\ldots\ldots\ldots (4)$$

The evaluation of $F(\omega)$, and hence θ, numerically can be performed by one of 3 methods.

(1) Expand $f(t)$ into a Fourier series. This provides $F(\omega)$ at a set of frequency points, submultiples of the fundamental frequency $= 2\pi/(t_2 - t_1)$ This method was employed to analyse and synthesise synthetic seismograms in a study of the spectral effects of truncation of a recorded seismogram (Appendix II).

(2) If $F(\omega)$ is required at other than these points, the integral (2) may be evaluated directly employing a numerical integration routine. In this case $F(\omega)$ will be an interpolated version of the Fourier series (Jeffreys, 1964). Results will be reliable provided the true spectrum varies smoothly in amplitude, as is the case with a Rayleigh wave train which is smoothly dispersed. There is no reason to expect singularities in attenuation, and the transfer function of the recorder varies smoothly in amplitude.

Using this approach we evaluate a finite Fourier transform of

$$f_m(t) = f(t).\Pi\{t - (t_2 - t_1)/2\}$$

where $\Pi(t)$ is the boxcar or gate function (Bracewell, 1965), having the transform sinc $(\omega/2\pi)$, the interpolating function in the frequency domain, mentioned above.

Thus $F_m(t) = F(t) * \text{sinc}\,(\omega/2\pi)$

$$\approx \int_{t_1}^{t_2} f_m(t)\cos(\omega\tau)\,d\tau - i\int_{t_1}^{t_2} f_m(\tau)\sin(\omega\tau)\,d\tau$$

The spectral effects of convolution by sinc $(\omega/2\pi)$ are examined in Appendix II.

Three commonly used methods to evaluate these integrals employ the trapezoidal rule, Filon's method or Simpson's rule.

The chosen technique employed a modified form of Simpson's rule with an end correction to calculate the derivatives of the function at its end points (Lanczos (1957) Ch. 8, 17).

If the digitised points are $f_m(t) = y_0, y_1, y_2 \cdots y_{2n}$ with separation Δt, Simpson's rule to approximate

$$A = \int_0^T f_m(t)\,dt \quad \text{where} \quad T = 2n\Delta t$$

is $A = 2\Delta t\,[y_0/2 + y_2 + \ldots + y_{2n}/2 + 2(y_1 + y_3 + \cdots + y_{2n-1})]/3$

This can be improved considerably with a knowledge of the $f_m(t)$ and $f_m'(t)$ at each point (loc. cit. p.417), leading to the more accurate approximation

$$A = \Delta t\,[14(y_0/2 + y_2 + \ldots + y_{2n}/2) + 16(y_1 + y_3 + \ldots + y_{2n-1}) + \Delta t(y_0' - y_{2n}')]/15$$

the derivatives, $f_m'(t)$, at all except the end points having cancelled.

$$y'_0 = (-21y_0 + 13y_1 + 17y_2 - 9y_3)/20$$

$$y'_{2n} = (-21y_{2n} + 13y_{2n-1} + 17y_{2n-2} + 9y_{2n-3})/20$$

This method was employed to evaluate $F_m(\omega)$ for all digitised Rayleigh wave trains.

(3) A third method of estimating $F(\omega)$ requires the expansion of the empirical data into a series of analytical functions which have known

analytical transforms. It is simply the more general approach of which the Fourier series (expansion into sines and cosines) is a special case.

This method, employing Laguerre functions, was used to find the transfer function of the seismograph from the Fourier transform of the recorded step function response. Laguerre functions are convenient in this instance, as they are transients, like step or impulse responses of dynamic systems, (Dean 1964). The method is discussed in Appendix VI describing the instrument response.

(b) The Spreading Correction

In this thesis we analyse seismograms recorded within 2000 km and often within 1000 km of the source, and due allowance must therefore be made to the phase of each spectral component, for the behaviour of the wave as it spreads from the source. This will depend on the nature of the source.

The primary aim of the investigation is to establish the correct dispersion either by

(a) Allowing for the initial phase factor (ϕ_o) for each earthquake, by determining its value

or (b) Annulling the effect of ϕ_o.

A simplified consideration of the problem assumes that the wave spreads symmetrically about a vertical axis through the source. Ewing, Jardetsky and Press (1957) ch. IV, solve the equation for vertical displacement in a layered waveguide for such a case. Because of the cylindrical rather than plane nature of the problem as was assumed in part (a) of this appendix, Bessel functions appear in the integrand which is solved using asymptotic expansions. The physical significance of these functions is revealed by the wave delay of $\frac{\pi}{4}$ which arises near the source e.g. Sato (1960) who compares the phase angle of the zero order Bessel function J_o with the cosine function, corresponding to the plane wave case.

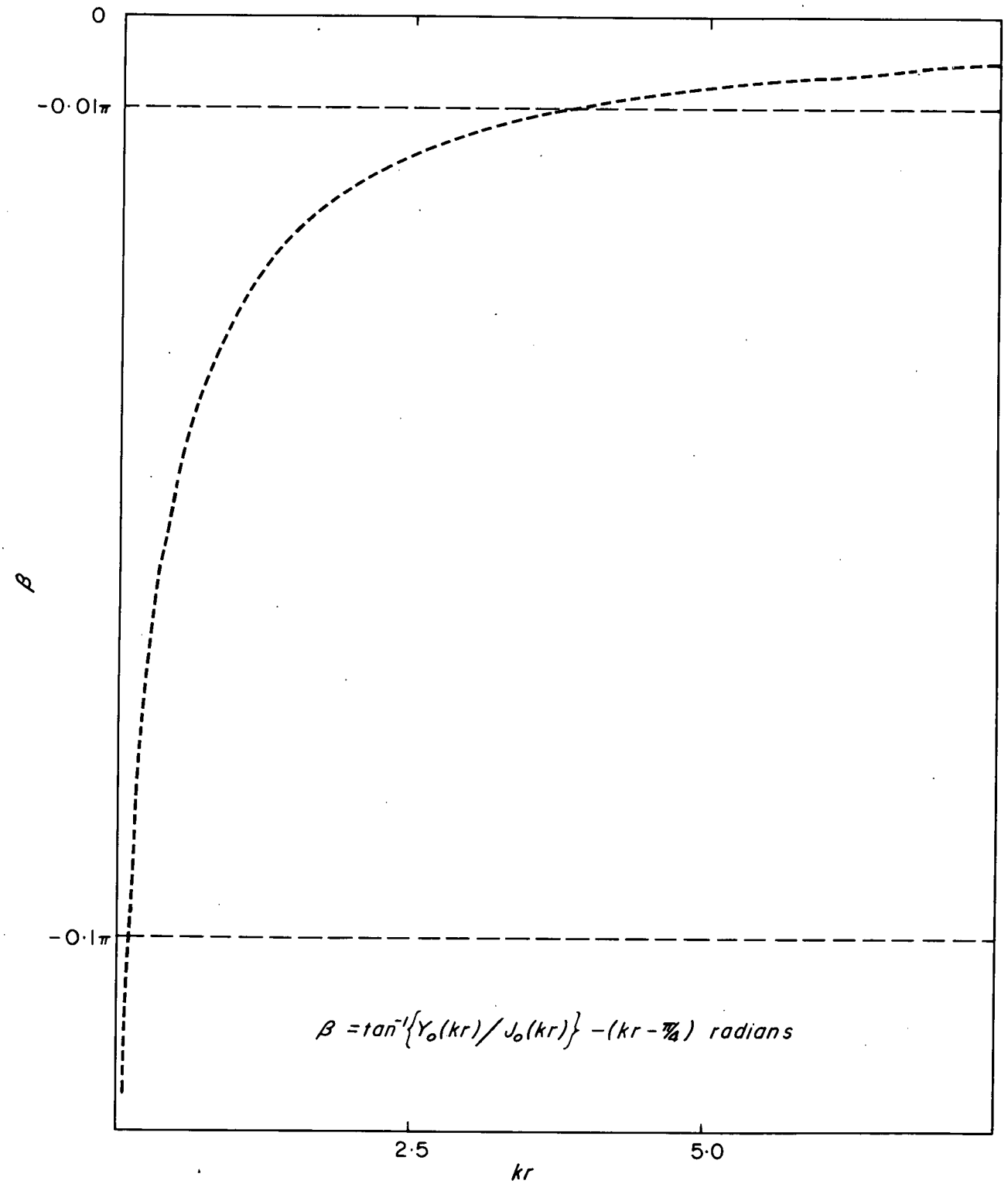

FIG. IA RELIABILITY OF ASYMPTOTIC EXPANSION OF $H_o^{(1)}(kr)$ PNG/B9-50

Knopoff and Schwab (1968), explain how this spreading correction depends on the attitude of the source.

For a vertical source, the expression for G in part (a) above is replaced by G_1, where $G_1 = G \cdot H_o^{(2)}(kr)$.

Now $H_o^{(2)}(kr) = J_o(kr) - i\, Y_o(kr) \approx (2/\pi kr)^{1/2} e^{i(\pi/4 - kr)}$

Tables of J_o, Y_o (Abramowitz and Stegun, 1965) can be used to compare $\tan^{-1}\left\{Y_o(kr)/J_o(kr)\right\}$ with the asymptotic argument $(\pi/4 - kr)$. Fig. IA shows these two functions to be within $.01\pi$ of each other provided $kr \gtrsim 4$ i.e. $r \gtrsim 4$ wavelengths, or about 200 km for periods of 40 to 60 seconds for most oceanic and continental waveguides.

Thus equation (4), part (a) above becomes

$C(\omega) = r\omega/(\omega t_1 - \Theta + \phi_o + \phi + \pi/4)$ in this case.

Knopoff and Schwab further show that for a horizontal source, a variation of $\pi/2$ occurs, thus

$C(\omega) = r\omega/(\omega t_1 - \Theta + \phi_o + \phi + 3\pi/4)$

Thus the apparent initial phase is $\phi_o + \pi/4 + \gamma$

where $\gamma = 0$ for a vertical source

and $\gamma = \pi/2$ for a horizontal source.

Hence a search for the correct dispersion curve by varying the apparent initial phase by $n\pi/2$, as described in section 2.1.2, will be consistent with either a horizontal or vertical source. For the intermediate case, and to test the frequency dependence of ϕ_o, Knopoff and Schwab (1968) computed a number of test dispersion curves for both fundamental and first higher modes, to estimate the magnitude of an additional correction factor γ_1 where

$$\gamma_1 = -\tan^{-1}\left[\tan\psi \cos\xi \left\{\frac{\dot{u}_s^*(D)}{\dot{u}_s(D)}\right\}_{H_j}\right]$$

where ψ = attitude of source vector to the vertical

ξ = angle between source vector and azimuth to the seismograph

D = depth of source

u_s^* = horizontal displacement component

w_s = vertical displacement

H_j = j^{th} mode for homogeneous layer structure (Harkrider, 1964)

Phase velocities for mode M_{21} were computed by Knopoff and Schwab (1968) for path lengths including 1000 and 2000 km which span those employed in this study. These exploratory curves imply probable variations of the order of ± 0.1 km/sec. for sources inclined at $\psi = 45^\circ$ and seem to be greatest at about 15 seconds period.

Table IA shows corresponding variations for the fundamental mode for path lengths ranging from 500 to 2000 km, based on phase velocities for model 117 (Appendix II). These variations, ΔC_1, are quite small, being less than ΔC_2, caused by ϕ_o variations of $\pm\pi/4$, and less than the expected observational scatter.

TABLE IA

Phase velocity variations for an inclined source.

[after Knopoff and Schwab (1968)].

	T = 10 sec.		T = 30 sec.		T = 50 sec.	
r (km)	$\lvert\Delta C_1\rvert$	$\lvert\Delta C_2\rvert$	$\lvert\Delta C_1\rvert$	$\lvert\Delta C_2\rvert$	$\lvert\Delta C_1\rvert$	$\lvert\Delta C_2\rvert$
500	.03	.08	.01	.20	.07	.24
1000	.02	.04	.01	.13	.03	.13
1500	.01	.03	.01	.07	.02	.08
2000	.01	.02	.00	.05	.02	.06

ΔC_1 = Difference between phase velocity for source inclined at 45° computed by single station techniques assuming $\phi_o = n\pi/2$, and correct phase velocity C.

$$= C - 1/\left\{1/C + (.0832T - 2.07)/r\right\}$$

ΔC_2 = Phase velocity variation corresponding to $\phi_o = \pi/4$.

APPENDIX II

TRUNCATION OF A RAYLEIGH WAVE TRAIN IN THE TIME DOMAIN

A seismogram is a recording of the superimposed motion of many modes of surface wave motion, possibly both direct or reflected and refracted, as well as body wave arrivals. In practice one must not only identify the wave train required but select the time window containing the pertinent data, while not excluding important information. Selection of a time window is critical to the study only if superfluous motion is within the frequency range of interest. In the extreme case of interference, an interfering wavetrain may be superimposed, in time, over most or all of the wavetrain required. Pilant and Knopoff (1964) have discussed ways of employing so called "moving" filters to eliminate the unwanted information. The bandwidth and passband of a digital filter are varied with time to reject what is expected to be most of the unwanted oscillation. This method can be employed only when the character of the unwanted data is known, and when the time sequence is sufficiently long to allow the proper use of digital filters.

This investigation concerns near earthquakes producing Rayleigh wave trains of comparatively short duration, and where interference occurred, its character could not be estimated, so that the moving filter approach was unsuitable. Moreover it was sometimes evident that much interference occurred at relatively short periods, i.e. 10 to 15 seconds or less, while the longer period motion was unaffected.

Initially several records were filtered with a low pass filter and a time window was selected according to the smooth form of the filtered wave so as to exclude any obvious "beat" effects. Figs. II-A,B,C,D show such records from the same region and the resulting dispersion curves. Fig. II-C is severely truncated, and the dispersion curve Fig. II-D for the truncated

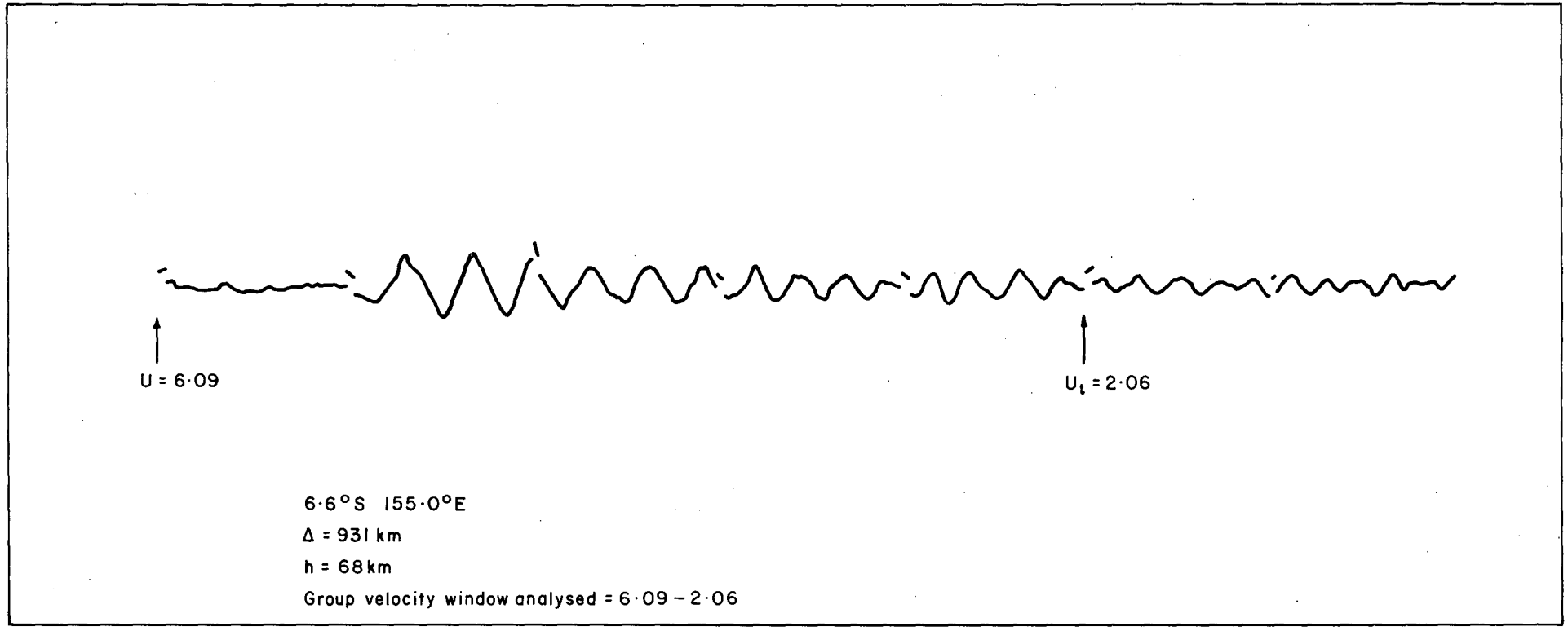

Fig. II A Unperturbed wavetrain for event 77 to Port Moresby

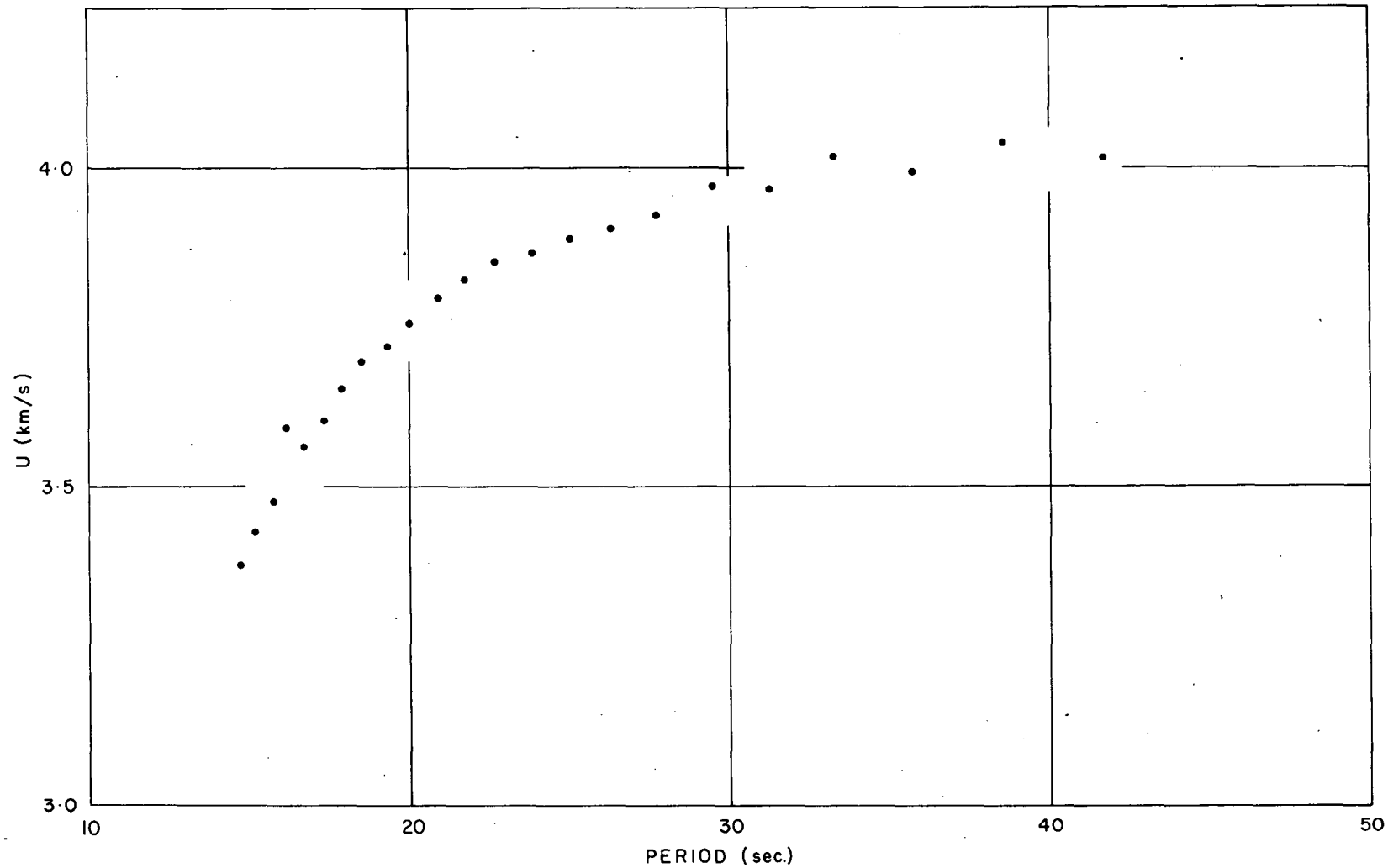

Fig. II B Computed dispersion profile for event 77 in Fig. II A
Displays higher gradient than Fig. II D, at short periods

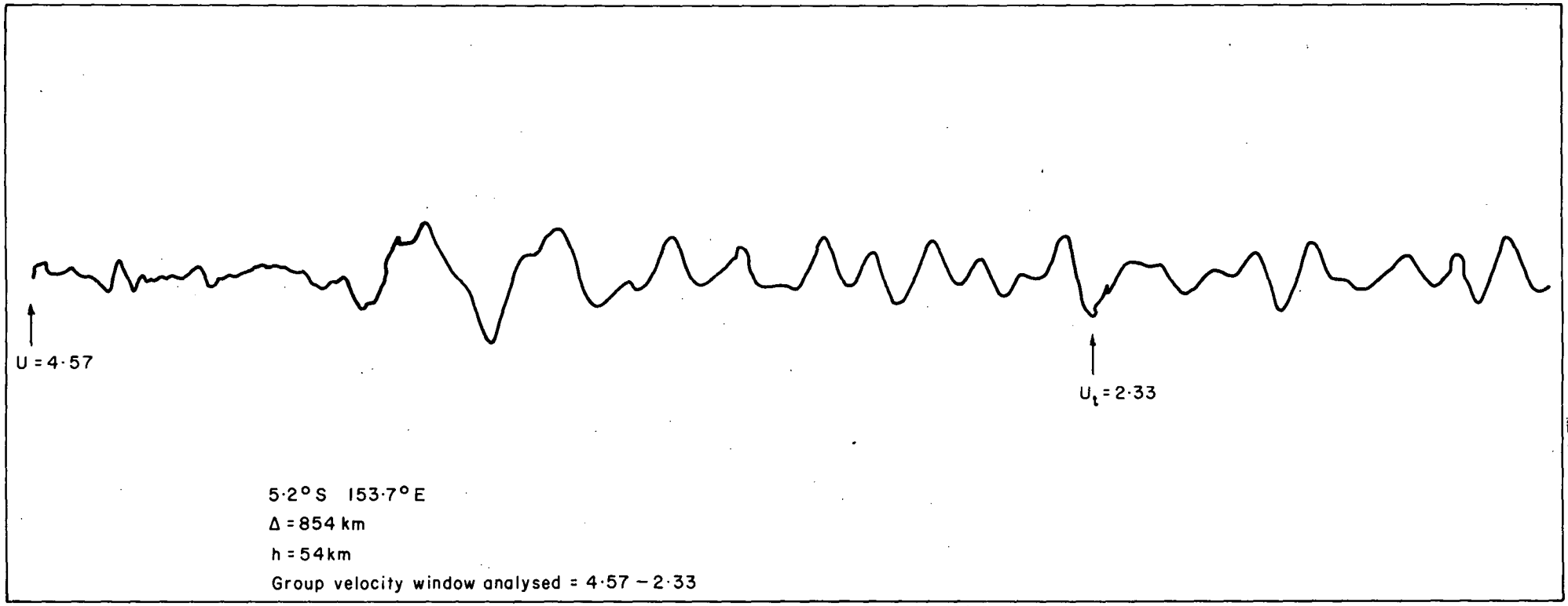

Fig. II C . Perturbed wavetrain for event 7 to Port Moresby

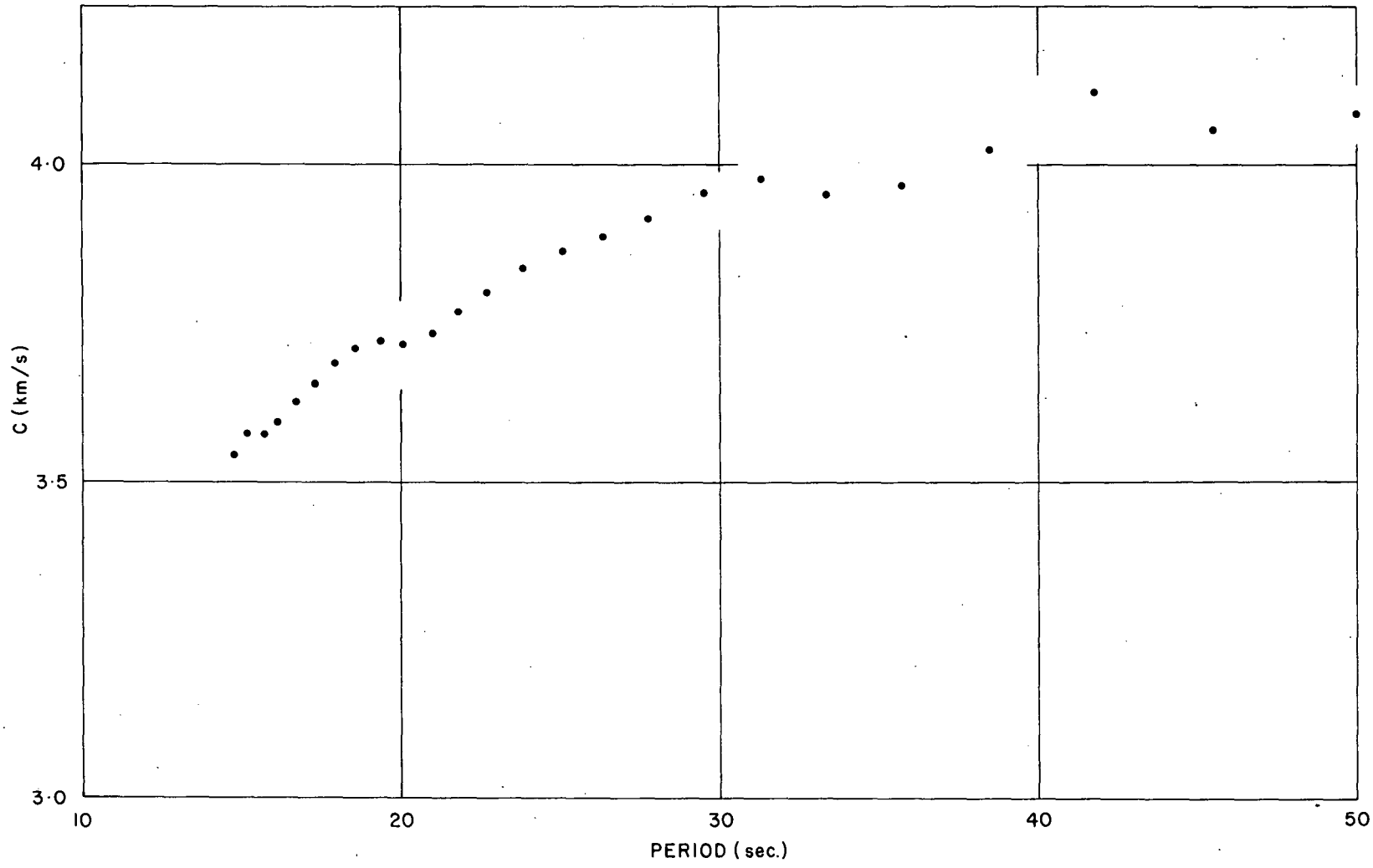

Fig. II D Computed dispersion profile for event 7 in Fig. II C
Displays lower gradient than Fig. II B, at short periods

time window, lacks the curvature normally present in the fundamental mode curve for a crust-mantle waveguide with the usual velocity contrast.

Two techniques were tried to guide the selection of the time window. In the first approach, a synthetic seismogram was progressively truncated in a sequence of tests to determine how the shape of the resulting dispersion curve varied. The method yielded a useful diagnostic dispersion characteristic.

Secondly, an analytical expression for a truncated Rayleigh wave was derived. This expressed the error in phase velocity in terms of the length of the time window. The method was not successfully applied as it employed an oversimplified expression for the complete Rayleigh wave.

Method 1

Phase and group velocities for the synthetic 2 layered crust-mantle model 117 (Table II-A) were computed, and are given in Table II-B. Note that a group velocity minimum occurs at about 20 sec. period.

Neglecting path attenuation one can construct a synthetic seismogram from the inverse Fourier Transform.

$$f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(\omega)\, e^{i\omega t}\, d\omega$$

Given $F(\omega) = \exp\{-i\,\theta(\omega)\}$ where $\theta(\omega) = \omega\Delta/C(\omega)$, $\omega_1 \leq \omega \leq \omega_2$

and $F(\omega) = 0$ otherwise

$$f(t) = \frac{1}{2\pi}\int_{\omega_1}^{\omega_2} \exp\{i\,(\omega t - \omega\Delta/C(\omega))\}\, d\omega$$

Truncation of f(t) was then performed and $F(\omega)$ reformulated from the direct transform

$$F(\omega) = \int_{-\infty}^{\infty} f(t)\, e^{-i\omega t}\, dt \qquad \text{where } f(t) = 0,\ t > t_T$$

The program used for these computations employed the Cooley - Tukey algorithm (Boothroyd, 1968) and enabled a series of truncations to be

TABLE II-A

MODEL 117

Layer	h.	α	β	ρ
	km	km/s	km/s	gm/cc
1	33.65	5.71	3.50	2.80
2	-	8.00	4.65	3.30

TABLE II-B

MODEL 117

Frequency cyc/sec.	C km/s	U km/s	Period sec.
.010	4.11971	4.00438	100.00
.012	4.09664	3.96565	83.33
.014	4.07434	3.92482	71.43
.016	4.05204	3.87930	62.50
.018	4.02900	3.82695	55.56
.020	4.00455	3.76618	50.00
.022	3.97812	3.69598	45.45
.024	3.94919	3.61608	41.67
.026	3.91738	3.52710	38.46
.028	3.88246	3.43080	35.71
.030	3.84439	3.33012	33.33
.032	3.80342	3.22915	31.25
.034	3.76007	3.13264	29.41
.036	3.71514	3.04528	27.78
.038	3.66963	2.97088	26.32
.040	3.62465	2.91172	25.00

TABLE II-B (cont)

Frequency cyc/sec.	C km/s		U km/s		Period sec.
.042	3.58120		2.86831		23.81
.044	3.54011		2.83972		22.73
.046	3.50196		2.82398		21.74
.048	3.46706	*	2.81874	*	20.83
.050	3.43551		2.82161		20.00
.052	3.40722		2.83045		19.23
.054	3.38202		2.84346		18.52
.056	3.35968		2.85920		17.86
.058	3.33993		2.87658		17.24
.060	3.32249		2.89477		16.67
.062	3.30712		2.91318		16.13
.064	3.29356		2.93138		15.62
.066	3.28162		2.94909		15.15
.068	3.27108		2.96611		14.71
.070	3.26178		2.98233		14.29
.072	3.25357		2.99766		13.89
.074	3.24631		3.01210		13.51
.076	3.23988		3.02562		13.16
.078	3.23420		3.03824		12.82
.080	3.22916		3.05000		12.50
.082	3.22469		3.06092		12.20
.084	3.22072		3.07106		11.90
.086	3.21720		3.08045		11.63
.088	3.21406		3.08913		11.36
.090	3.21128		3.09715		11.11
.092	3.20879		3.10456		10.87

TABLE II-B (cont)

Frequency cyc/sec.	C km/s	U km/s	Period sec.
.094	3.20658	3.11140	10.64
.096	3.20461	3.11770	10.42
.098	3.20285	3.12350	10.20
.100	3.20128	3.12884	10.00

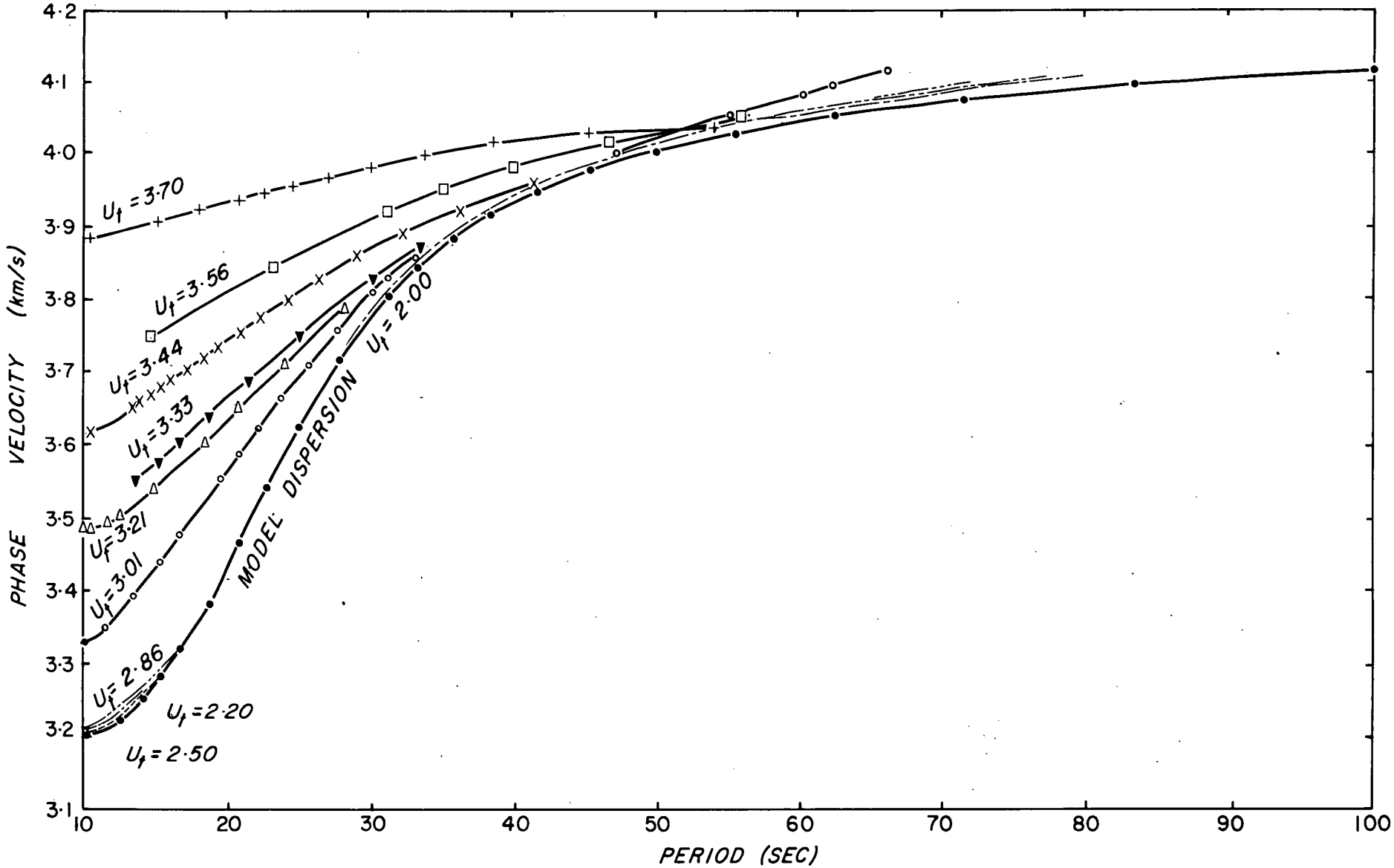

FIG. II E COMPARISION OF MODEL PHASE VELOCITIES WITH THOSE DERIVED BY SPECTRAL ANALYSIS OF TRUNCATED SYNTHETIC SEISMOGRAM COMPUTED FROM MODEL PHASE VELOCITIES (TABLE 2)

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performed on a synthetic Rayleigh wave for the $C(\omega)$ tabled, and Δ = 1000 km. Results are plotted in Fig. II-E showing the resulting phase velocities for different truncations, specified in terms of velocity, U, corresponding to arrival at time of truncation, compared to the true model phase velocities. Little perturbation is seen until the truncation time precedes the group arrival of the stationary phase (2.82 km/sec.). Subsequent dispersion curves display a pronounced lack of curvature noted above.

Resulting from these tests, care was taken to ensure that the time window of seismogram used for interpretation extended to group travel times corresponding to $U \lesssim 2.0$ km/sec.

Method 2

Pilant and Knopoff (1964) considered a problem where $f(x;t) = f_1(x;t) + af_1(x;t - t_f)$ was taken as the contaminated wave at distance x from the origin. Keeping x invariant, the Fourier spectrum is

$$F(x;\omega) = F_1(x;\omega) + aF_1(x;\omega)\exp(-i\omega t_f) \quad \ldots\ldots\ldots\ldots (1)$$

(use of upper case letters signifies a Fourier transform of the corresponding lower case function).

The modulating factor $(1 + a\exp(-i\omega t_f)$ is shown by Pilant and Knopoff to be significant at certain frequencies and caused them to speculate (ibid p35) that truncation of the later portions of such a contaminated waveform may still result in the remaining data at low frequencies being heavily modulated, although in practice the coefficient "a" may well be frequency dependent, having small values at the low frequencies.

The case considered here is slightly different, and may have at least an equal practical significance. The primary and contaminating signals are f_1 and f_2 respectively. Assuming that f_2 can be removed entirely by truncation, we examine the spectrum of the remaining function.

Initially,

$$f(x;t) = f_1(x;t) + f_2\{x;(t - t_f)\} \quad \ldots\ldots\ldots\ldots (2)$$

If g(t) is the "boxcar" or "gate" function,

$$\Pi\left\{(t - t_x)/t_y\right\} = 1, \quad t_x - t_y/2 \leq t \leq t_x + t_y/2$$

$$= 0, \text{ otherwise}$$

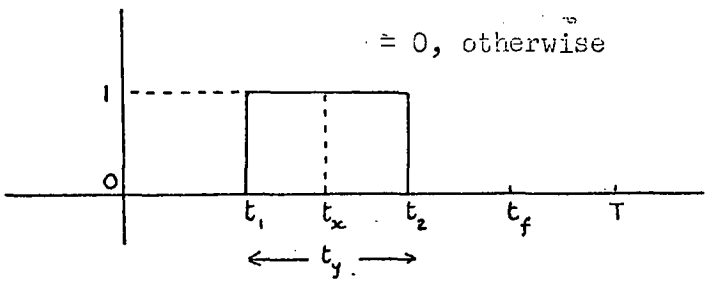

Fig. II-F

and we suppose that t_x and t_y are chosen such that

$$f_2(t - t_f) \cdot \Pi(t - t_x)/t_y) = 0$$

then we redefine $f(x;t) = f_1(x;t)\ g(t)$.

Whence (omitting, for convenience, the "fixed" variable, x

$$F(\omega) = F_1(\omega) * G(\omega) = A(\omega) \exp(-i\theta(\omega)) \quad \ldots\ldots\ldots\ldots (3)$$

where A is real.

$G(\omega)$ will have the form of a "sinc" function.

The amplitude and phase modulation of $F_1(\omega)$ is now not as straightforward to evaluate as in equation (1) and depends on the form of $f_1(t)$. If we define A_1 (real) and θ_1 by

$F_1(\omega) = A_1(\omega) \exp(-i\theta_1(\omega))$, we seek to establish

$$\Delta\theta(\omega) = \theta(\omega) - \theta_1(\omega) \quad \ldots\ldots\ldots\ldots (4)$$

A useful concept is to treat t_1 and t_2 (Fig. II-F) as bounding a group velocity "window" and see how $\Delta\theta(\omega)$ is related to group arrival time t_ω of f_1 as this changes in relation to t_x and to the ratio $t_y/(2\pi/\omega)$.

To facilitate this we use a form for $f_1(t)$ first developed by Aki (1960) and later used by Alexander (1963)

$$\text{if } F_1(\omega) = A_1(\omega) \exp(-i\theta_1(\omega) = A_o \qquad \omega_1 < \omega < \omega_2$$

$$= 0 \qquad \ldots\ldots\ldots\ldots (5)$$

where $\theta_1(\omega) = \omega x / C(\omega)$, $C(\omega)$ being the phase velocity, and A_o has dimensions appropriate for the problem.

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* Throughout this treatment the symbols employed by Bracewell (1965) are used for basic functions.

Then dividing the range $\omega_2 - \omega_1$ into n portions such that $\omega_2 - \omega_1 = \sum_{j=1}^{n} \Delta\omega_j$, it can be shown that a first order approximation of a series expansion for $f_1(t)$ is given by

$$f(t) = 2A_o \sum_{j=1}^{n} \Delta\omega_j \cdot \cos(\omega_j(t-\tau_j)) \cdot \sin[\Delta\omega_j(t-t_j)/2] / [\Delta\omega_j(t-t_j)/2] \qquad (6)$$

(Aki 1960) where

t_j = group travel time = x/U_j

τ_j = phase travel time = x/C_j

In this way the Rayleigh wave is treated as the superimposition of a number of group arrivals centred around each ω_j and having the form of a "sinc" envelope modulating a cosine wave, the peak of which moves with group velocity $U(\omega_j)$.

i.e. from equation (3), we seek the Fourier transform of

$$f(t) = g(t) \cdot f_1(t)$$

$$= 2A_o g(t) \sum_{j=1}^{n} h_j(t) \cdot k_j(t) = 2A_o \sum_{j=1}^{n} h_j(t) \cdot k_j(t) \cdot g(t) \qquad (7)$$

where $g(t) = \Pi[(t - t_x)/t_y]$ 8(a)

$h_j(t) = 2\pi\Delta s_j \ \mathrm{sinc}(\Delta s_j(t - t_j))$ 8(b)

$k_j(t) = \cos[\omega_j(t - \tau_j)] = \cos[2\pi s_j(t - \tau_j)]$ 8(c)

where ω = frequency (radians/sec.)

s = frequency (cycles/sec.)

The transforms of g, h, k, are, respectively

$$G(s) = t_y \ \mathrm{sinc}(st_y) \exp\{-i2\pi st_x\} \qquad 9(a)$$

$$H_j(s) = 2\pi\Pi(s/\Delta s_j) \exp\{-i2\pi st_j\} \qquad 9(b)$$

$$K_j(s) = \Pi\Pi(s/2s_j) \exp\{-i2\pi s\tau_j\} /2s_j \qquad 9(c)$$

Now, from (7) we have

$$F(s) = 2A_o \sum_{j=1}^{n} K_j(s) * J_j(s) \qquad (10)$$

where $J_j(s) = H_j(S) * G(s)$

Substituting the expressions 9(a), 9(b)

$$J_j(s) = 2X_j(s) \int_{-\infty}^{\infty} \frac{1}{s'} \left\{ \sin(\alpha s') \cos(\beta_j s') - i \sin(\alpha s') \sin(\beta_j s') \right\} \Pi\left(\frac{s-s'}{\Delta s_j}\right) ds' \quad (11)$$

where $X_j(s) = \exp(-i2\pi s t_j)$

$\alpha = \pi t_y$

$\beta_j = 2\pi(t_x - t_j)$

Now $\Pi\left(\frac{s-s'}{\Delta s_j}\right) = 1, \quad s - \frac{\Delta s_j}{2} \leq s' \leq s + \frac{\Delta s_j}{2}$

$= 0$, otherwise

Substituting $\epsilon = s - \frac{\Delta s_j}{2}$, $\eta = s + \frac{\Delta s_j}{2}$ equation (10) becomes

$$J_j(s) = 2X_j(s) \int_{\epsilon}^{\eta} \frac{1}{s'} \left\{ \sin(\alpha s') \cos(\beta_j s') - i \sin(\alpha s') \sin(\beta_j s') \right\} ds' \quad (12)$$

There are three cases to consider:

Case 1 We consider only those frequencies with group arrivals within the limits of t_y

i.e. $\alpha + \beta_j = \gamma_j$, $\alpha - \beta_j = \mu_j$ are both positive

and ϵ and η have the same sign.

Expanding the trigonometric functions in the usual way, making appropriate changes of variable we find

$J_j(s) = \pm X_j(s) \left[\mathrm{Re}_j(s) + i \, \mathrm{Im}_j(s) \right]$ ..... (13), adopting the sign of ϵ and η

where $\mathrm{Re}_j(s) = \mathrm{Si}(|\eta\gamma_j|) - \mathrm{Si}(|\epsilon\gamma_j|) + \mathrm{Si}(|\eta\mu_j|) - \mathrm{Si}(|\epsilon\mu_j|)$

and $\mathrm{Im}_j(s) = \mathrm{Ci}(|\eta\gamma_j|) - \mathrm{Ci}(|\epsilon\gamma_j|) - \mathrm{Ci}(|\eta\mu_j|) + \mathrm{Ci}(|\epsilon\mu_j|)$

where Si and Ci are the conventional sine and cosine integrals.

Case 2 μ, γ are positive, ϵ and η have opposite signs.

This occurs as $s \to s_j$ i.e. $\eta \longrightarrow \Delta s_j/2$, $\epsilon \longrightarrow -\Delta s_j/2$

The imaginary part of $J_j(s)$, eq. (12) is then solved by expanding $\sin(\alpha s')$ and $\sin(\beta s')$

When $s = s_i$ this component vanishes. i.e. $\mathrm{Im}_j(s) = 0$.

Case 3 γ and μ have opposite signs. This occurs only if we consider frequencies whose group arrivals fall outside the limits of t_y.

Proceeding as in Case 2 we find that

$$Im_j(s) = \frac{\alpha}{2}\beta_j \{s\Delta s_j\} + \ldots .$$

From (10)

$$F(s) = 2A_o \sum_{j=1}^{n} \int_{-\infty}^{\infty} K_j(s').\ J_j(s-s')\ ds' \qquad (14)$$

Substituting 9(c) and (13) into (14) and simplifying

$$F(s) = A_o \sum_{j=1}^{n} \cos(2\pi s_j \tau_j)\left[P_j(s-s_j) + iQ_j(s-s_j)\right] \qquad (15)$$

where $P_j = \cos\{2\pi(s-s_j)t_j\}\ Re_j(s) + \sin\{2\pi(s-s_j)t_j\}\ Im_j(s)$

$$Q_j = \cos\{2\pi(s-s_j)t_j\}\ Im_j(s) - \sin\{2\pi(s-s_j)t_j\}\ Re_j(s)$$

i.e. $F(s) = A_o \sum_{j=1}^{n} (Y_j + iZ_j)$ where $Y_j = \cos(2\pi s_j \tau_j) P_j$

$$Z_j = \cos(2\pi s_j \tau_j) Q_j$$

Thus from (3), (4) and (5)

$$\theta(s) = \tan^{-1}\left\{ \sum_{j=1}^{n} Z_j \Big/ \sum_{j=1}^{n} Y_j \right\}$$

and $\Delta\theta(s) = \theta(s) - \tan^{-1}(2\pi s_x / C(s))$

A program was written to evaluate $\theta(s)$ and $\Delta\theta(s)$ employing the same model phase and group velocities as method 1, above, but results were disappointing. The most probable source of error lies in the adoption of equation (6) which is a simplified form of the true $f_1(t)$. Inclusion of higher order terms would make the subsequent development a very unwieldy one. This was not pursued and the technique was discarded.

APPENDIX III

GROUP VELOCITY

Three methods of computing group velocity are used.

(a) Simple hand analysis

Alternate peak or zero crossing times are plotted against the order number of their arrival. Period arrival times are read from the intersection of tangents with a curve of best fit placed visually through these points. Travel times, thus evaluated, determine the group velocity.

Thus $U = r/t$, t = travel time

Errors arise from poor determinations of both r and t.

For example a precision of 2 or 3% in U can be expected from errors of $\pm$ 25 km in r of 1000 km, and $\pm$ 1 sec. in origin times.

Thomson and Evison (1962) also pointed to the need to correct apparent period when wavetrains having rapid dispersion are analysed. These corrections arise from the transfer function of the seismograph and must be computed iteratively

$$T = T'(1 - \phi' . dT/dt)$$

where $\phi' = d\phi/d\omega$, the group delay of the seismograph

T = true ground period

T' = apparent ground period determined from the hand analysis plot.

The method is satisfactory, provided the dispersion is not unduly rapid.

(b) The digital filter technique

Adapting and generalising an approach by Aki (1960), Alexander, (1963) devised a technique for measuring group velocities using narrow bandpass digital filters.

Subsequently, Crampin and Bath (1965) used essentially the same approach, but in a restricted way, by applying visual interpretative methods to data filtered through a fixed frequency window. A smooth succession of group velocities is determined, but this technique cannot readily isolate group velocities where the velocity gradient changes rapidly (or reverses). Alexander showed that repeated passes, increasing the centre frequency of the passband by very small amounts, permits this in some circumstances.

Separation of modes, superimposed in the time domain becomes possible although resolution is still poor near points of intersection of dispersion curves in the group velocity: frequency "plane".

This method is the basis of measurements of group velocity for the higher Rayleigh mode (Chapter III).

At distance x from the source, the spectrum of the seismic wave (for a single mode) is

$$F(\omega;x) = |A(\omega;x)| \exp\{-i\theta(\omega;x)\} \quad \ldots\ldots\ldots\ldots (1)$$

where A and θ incorporate the amplitude and phase characteristics of the source spectrum and instrumental transfer function, and also the path attenuation (real). ω is measured in radians/sec. If we filter the data with an ideal narrow bandpass filter h(t), having the Fourier transform

$$H(\omega) = 1, \qquad \omega_1 < |\omega| < \omega_2$$

$$= 0, \qquad \text{otherwise}$$

Then the filtered data

$$y(t;x) = (1/2\pi) \int_{-\infty}^{\infty} F(\omega;x)\, H(\omega) \exp(i\omega t)\, d\omega$$

can be expressed as the convolution of the transforms of F and H

$$y(t;x) = f(t;x) * h(t) \quad \ldots\ldots\ldots\ldots (2)$$

Replacing the limits of integration by ω_1 and ω_2, Alexander showed that

$$y(t;x) \approx 2\,\mathrm{Re}\left[\exp\{i\alpha(t)\} \sum_{n=0}^{\infty} \frac{1}{n!} \left(\partial^n A/\partial\omega^n\right)_{\bar{\omega}} \partial^n \left\{(-i)^n \sin(\Delta\omega(t-\bar{t}))/(t-\bar{t})\right\}/\partial t^n\right] \quad (3)$$

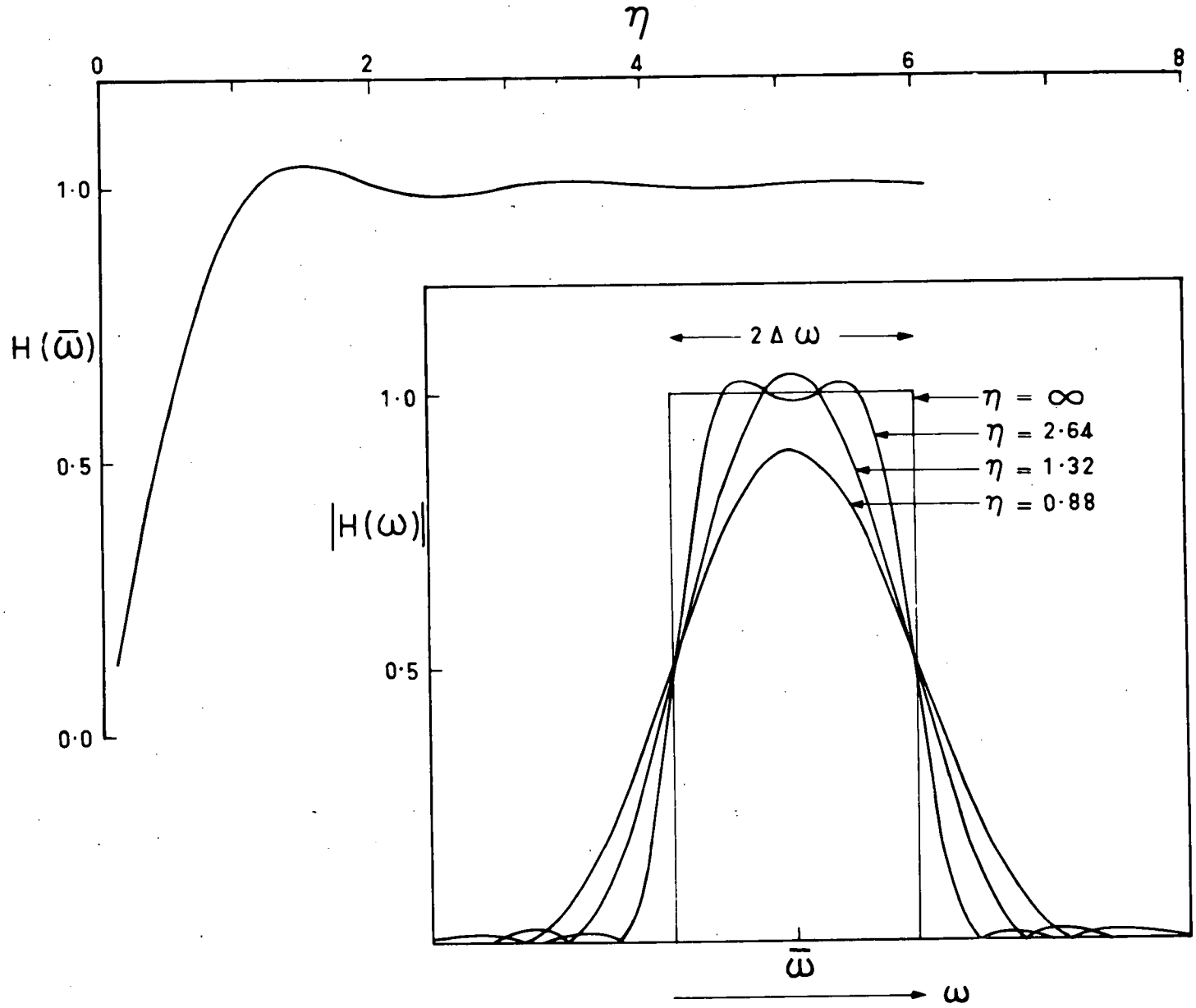

FIG. III A BANDPASS FILTER

PNG/89-47

(Based on G82/2-89)

where $\bar{\omega} = (\omega_1 + \omega_2)/2$

$\Delta\omega = (\omega_2 - \omega_1)/2$, half bandwidth of filter

$\alpha(t) = \bar{\omega}(t - x/C(\bar{\omega})) - \phi(\bar{\omega}) - \phi_o(\bar{\omega})$ [$\equiv \theta$ (p. 166)]

$\bar{t}$ = recorded group arrival time = $x/U(\bar{\omega}) + \phi'(\omega) + \phi_o'(\omega)$

$\phi'(\omega)$ = gradient of instrumental phase shift (obtained from theoretical instrument response) [$\equiv -\phi'(\omega)$ (p. 165)]

$\phi_o'(\omega)$ = gradient of initial phase (assumed to be zero) [$\equiv -\phi_o'(\omega)$ (p 165)]

Provided $\partial A/\partial\omega << A$, we need only retain the dominant (first) term in the expansion of (3), thus

$$y(t;x) \approx 2A(\bar{\omega};x)\left\{\sin(\Delta\omega(t-\bar{t}))/(t-\bar{t})\right\}\cos\alpha(t) \qquad (4)$$

which maximises as $t \to t'$, the group travel time. Thus the filtered data appears as a carrier of frequency ω, modulated by a $\sin(\Delta\omega t)/\Delta\omega t$, or "sinc" function envelope (Bracewell, 1965). Repeated passes, for a succession of $\bar{\omega}$ values, allows $\bar{t}$ to be determined for a range of frequencies.

A programme to perform the convolution expressed by equation (2), employed the following filter function, $\bar{h}(t)$, to approximate h(t)

$$\bar{h}(t) = \left\{(\omega_2/\pi)\,\mathrm{sinc}(\omega_2 t/\pi) - (\omega_1/\pi)\,\mathrm{sinc}(\omega_1 t/\pi)\right\}\cos(\pi t/T), \quad |t| < T \qquad (5)$$

$$= 0, \quad \text{otherwise.}$$

This filter is based on the ideal lowpass filter of Lanczos (1957, p267), shifted in frequency, and is the same as the one used by Crampin and Bath (1965) apart from the weighting function, $\cos(\pi t/T)$. Lanczos (1957, p226) compares the effect of the two weight functions.

The amplitude variation, $H(\omega)$, of the filter within the passband was not discussed by Crampin and Bath and critically depends on the memory time T, which is governed by the length of data to be filtered, (see Fig. III-A, inset).

A bandpass filter is ineffective for practical purposes unless at least the frequencies at its centre are passed without attenuation. Fig. III-A discloses the relation between the amplitude of the passband centre, $H(\bar{\omega})$, bandwidth, and memory time, T. $H(\bar{\omega})$ is shown as a function

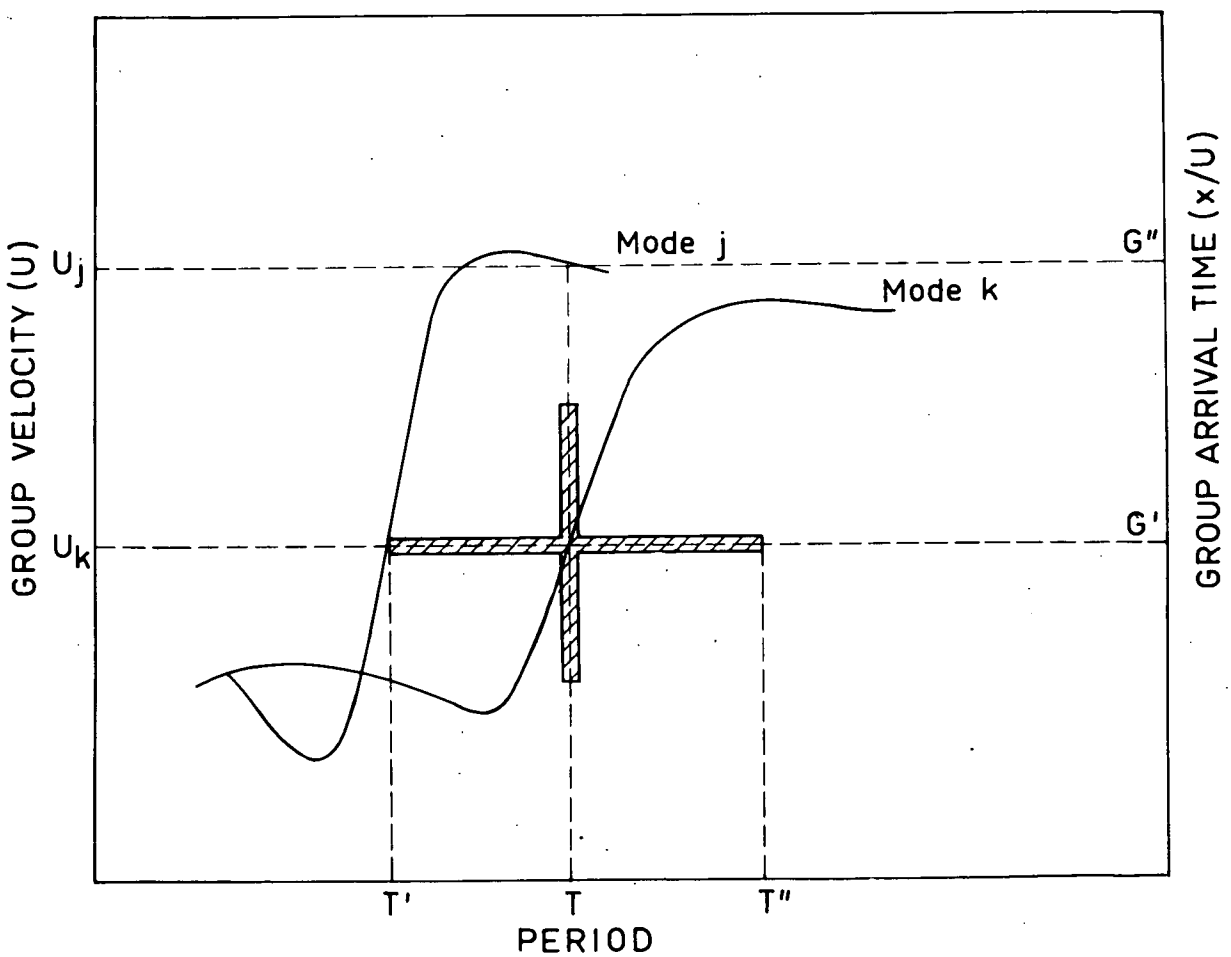

FIG. III B MODE SEPARATION CRITERA PNG/B9-48

(Based on G82/2-86)

of $\eta = T\Delta\omega/2\pi$. Fig. III-A indicates that useful filters are such that $\eta \geq 1$.

The programme output included group velocity, $y(t)$ and $Y(t)$ for each point, where

$$Y(t) \approx \int_{t_1}^{t_2} y^2(\tau)\, d\tau \quad , \quad t_1 = t - 2\pi/\Delta\omega \, , \; t_2 = t + 2\pi/\Delta\omega$$

$Y(t)$ is an envelope of the form sinc^2 (Bracewell, 1965) having an "equivalent width" spanned by $t \pm \pi/\Delta\omega$ (ibid p. 150).

Fig. III-B illustrates how resolution is restricted by the proximity of adjacent dispersion curves of modes j and k (presumed to be excited with amplitudes of the same order of magnitude). Cross hatching indicates opposing bandwidth constraints imposed by features in both directions, when searching for a group arrival (T, U_k) i.e. $\bar{\omega} = 2\pi/T$; $\bar{t} = x/U_k$ at a distance x.

(a) In the vertical direction a minimum bandwidth of $2\Delta\omega > 4\pi/(G'' - G')$ is necessary if peaks in $Y(t)$ corresponding to modes j and k, are to be resolved.

(b) In the horizontal direction, the bandwidth should be sufficiently small to avoid accepting appreciable energy at period T' i.e. $2\Delta\omega < 2\pi(1/T' - 1/T)$. Generally, bandwidths ranged from .03 to .08 c/s.

(c) Direct differentiation

Group velocities may be derived by direct numerical differentiation of a phase velocity dispersion curve i.e. $U(\omega) = d\omega/dk$. Attempts were made to fit polynomials to theoretical phase velocities in both least squares and Chebyschev (minimax) senses. The algorithm by Boothroyd (1968) was used for the latter.

Fig. III-C shows group velocities computed by both techniques from a set of theoretical model phase velocities which were rounded to 3 significant figures, to simulate experimental data precision, before attempting a polynomial fit. Comparison with the known model velocities shows loss of control at both ends of the profile for both methods

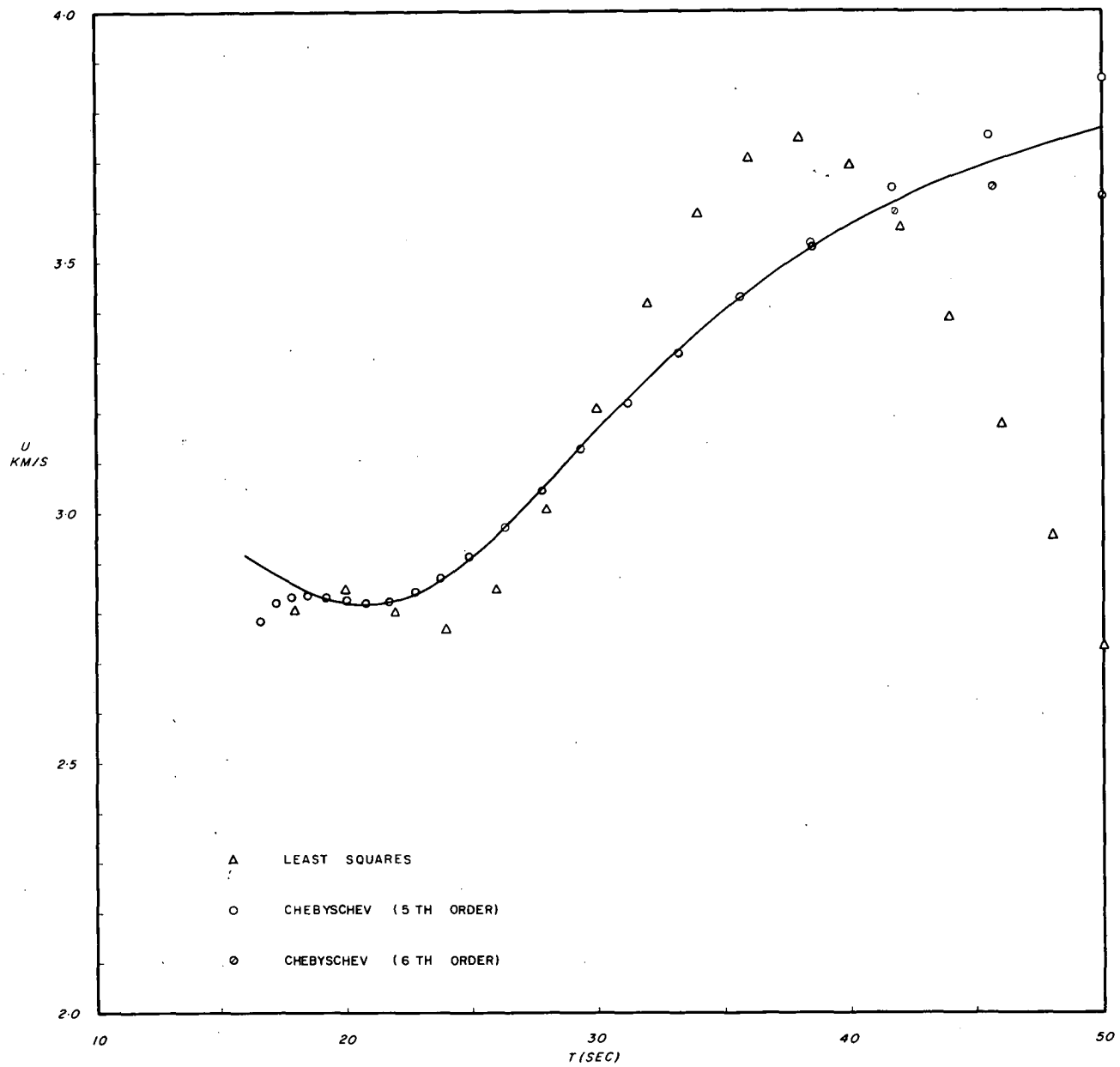

FIG. III C COMPARISON OF GROUP VELOCITIES. SOLID CURVE INDICATES CORRECT MODEL VELOCITIES. SYMBOLS DEFINE VELOCITIES DERIVED FROM POLYNOMIAL FITTED TO MODEL PHASE VELOCITY PROFILE

PNG/B9-49

(Based on G82/2-71)

but departures are much smaller for the Chebyschev fit because this method ensures a more uniform distribution of residuals throughout the profile, and hence a better control of the polynomial gradient.

Some improvement can be made at the critical long period end by averaging the group velocities derived from polynomials of different order, chosen so that the slopes at the long period end are respectively too high and too low, and their mean is usually a better approximation than either.

Usually, polynomials of 5th and 6th order gave residuals of opposite sign, and slopes with the required characteristics at the long period end-point of the data. Fig. III-C exhibits group velocities from two such polynomials at the long period end.

APPENDIX IV

CONVERGENCE OF THE PHASE VELOCITY INVERSION METHOD

Results of tests conducted on synthetic data to assess the influence of layer thickness and precision of observed phase velocities on the convergance of the inversion technique for fitting earth models to observed phase velocity profiles, are explained in this Appendix.

A set of phase velocities was computed for the model shown in Table 1a. These velocities were compiled into 2 sets of "observed" data, set A to 5 place accuracy, set B to 2 place accuracy (Table 2). Starting models X and Y (Table 1b, 1c) were then inverted against each of set A and B. Model X differs only in shear velocity from the correct solution, and model Y is additionally perturbed in that layers 2 and 3 are subdivided. Only mantle shear velocities (starting values 4.50 km/sec.) were allowed to float.

The shear velocity values found in successive iterations for each problem i.e. A-X, A-Y, B-X, B-Y are displayed in Figs. IV A, B, C together with RMS deviations of computed minus observed phase velocities. Sample partial derivative profiles in both modes, M_{11} and M_{21}, for model Y are shown in Fig. IV D. Maximum values of each of these exceed the data precision, yet it is clear that subdivision of the layers has produced an unstable solution particularly for split layers 2 - 5 in case B-Y (Fig. IV C) when limited precision data was employed, but not so in case B-X where layer thicknesses were unaltered. Chapter 3 shows the thickness of the principal lobe of the vertical displacement profile as a function of period for two standard earth models. These profiles would not differ greatly for the model considered here, and it can be seen that 20 km segments of the model are small compared with the thickness of this lobe for periods where the sensitivities (Fig. IV D) are high. The variation of displacement amplitude is greater over a 40 or 50 km thick segment of the model which is therefore better controlled. The ratio of layer

thickness of the "depth span" of the main lobe of the displacement profile appears to be one criterion by which model layers can be judged as being too thin.

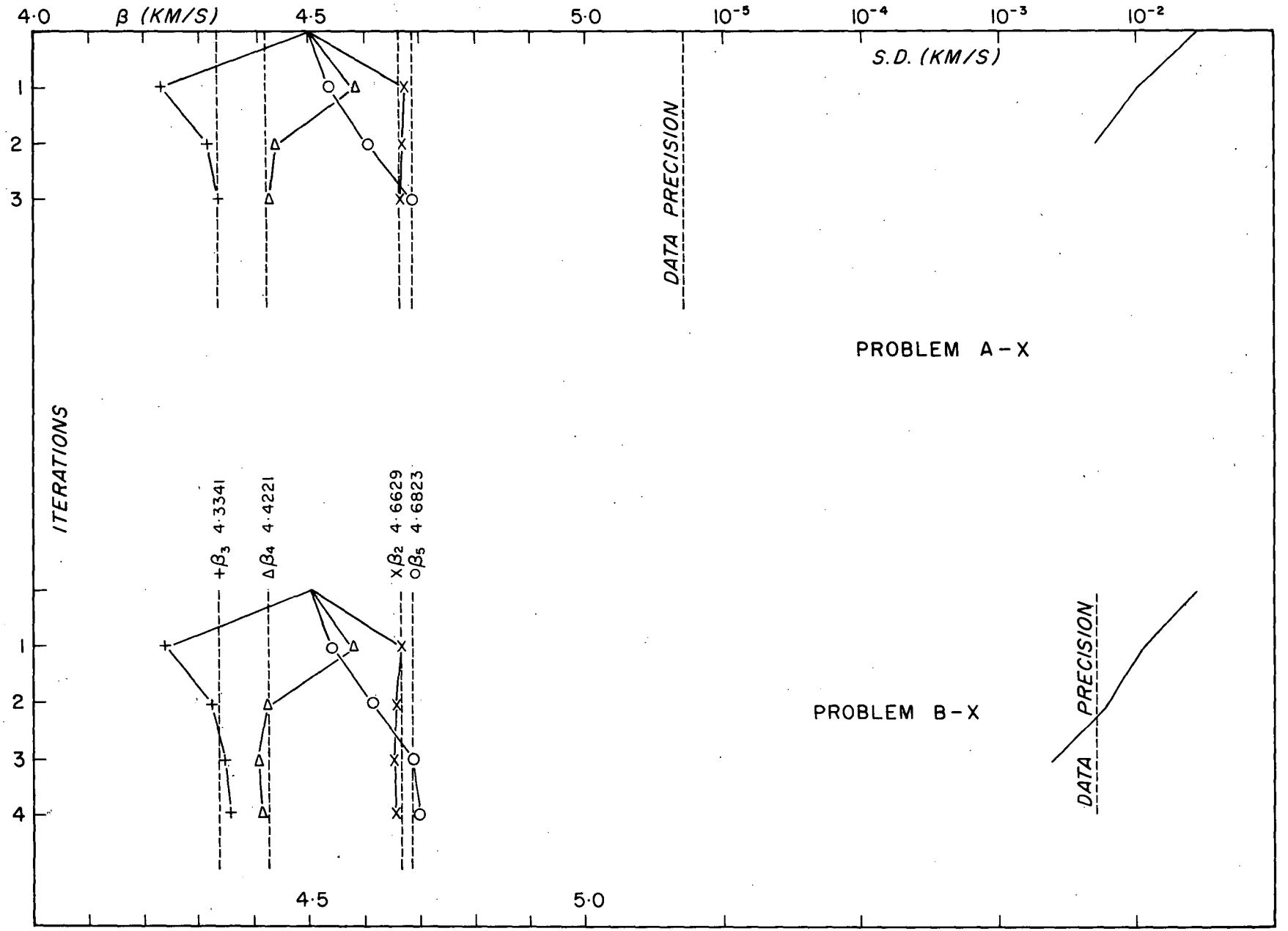

FIG IV A – β CONVERGENCE FOR SUCCESSIVE ITERATIONS GOOD FOR BOTH CASES WHERE MODEL LAYERS ARE THICK. S.D. IN PROBLEM B–X SHOWS β VALUES WILL NOT IMPROVE FURTHER. CORRECT β VALUES SHOWN BY DOTTED LINES.

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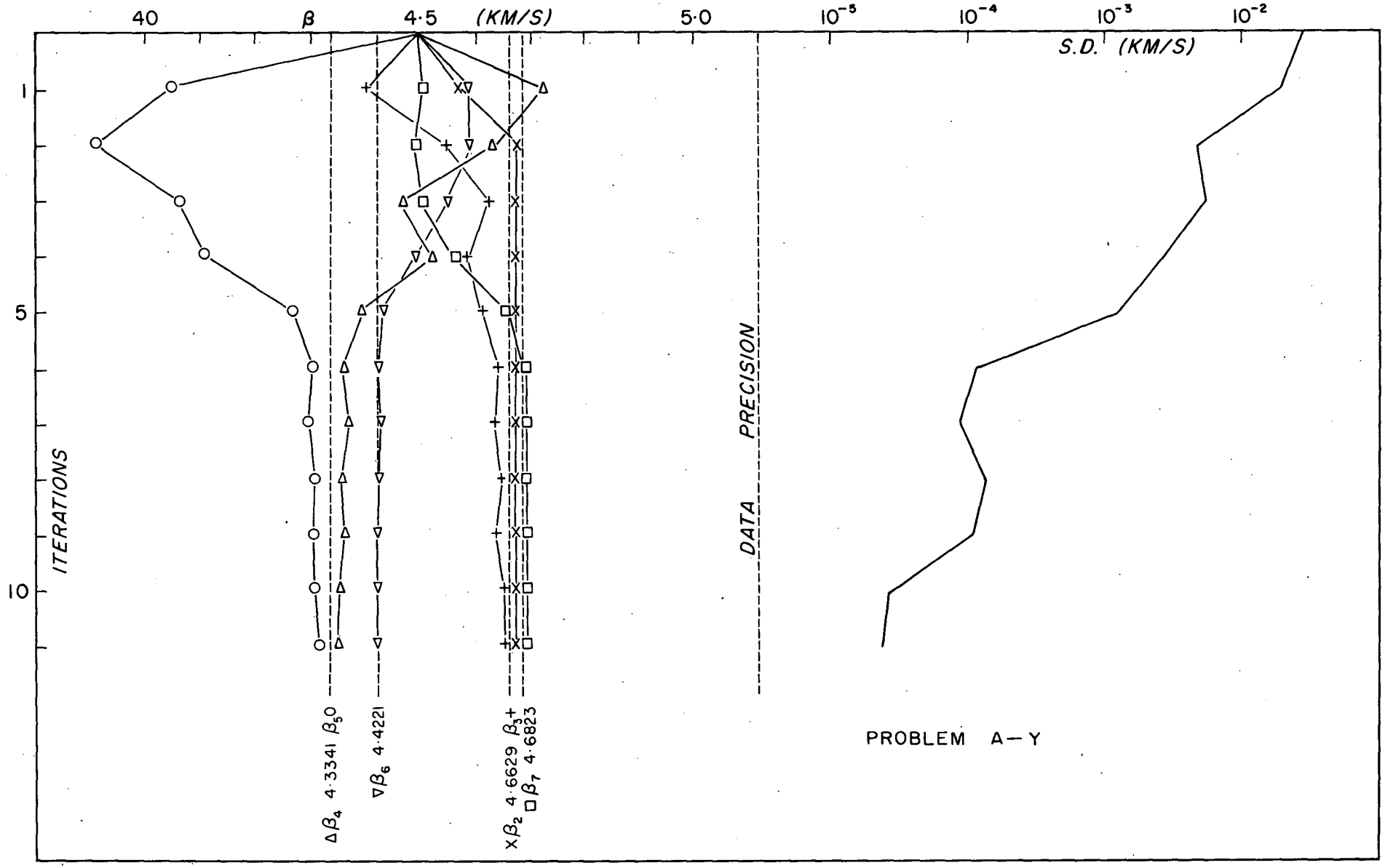

FIG IVB – β CONVERGENCE SLOW BUT POSITIVE FOR MODEL HAVING SPLIT LAYERS WHILE RETAINING FIVE PLACE ACCURACY OF EXPERIMENTAL DATA. S.D. INDICATES β VALUES NOT YET FINALISED.

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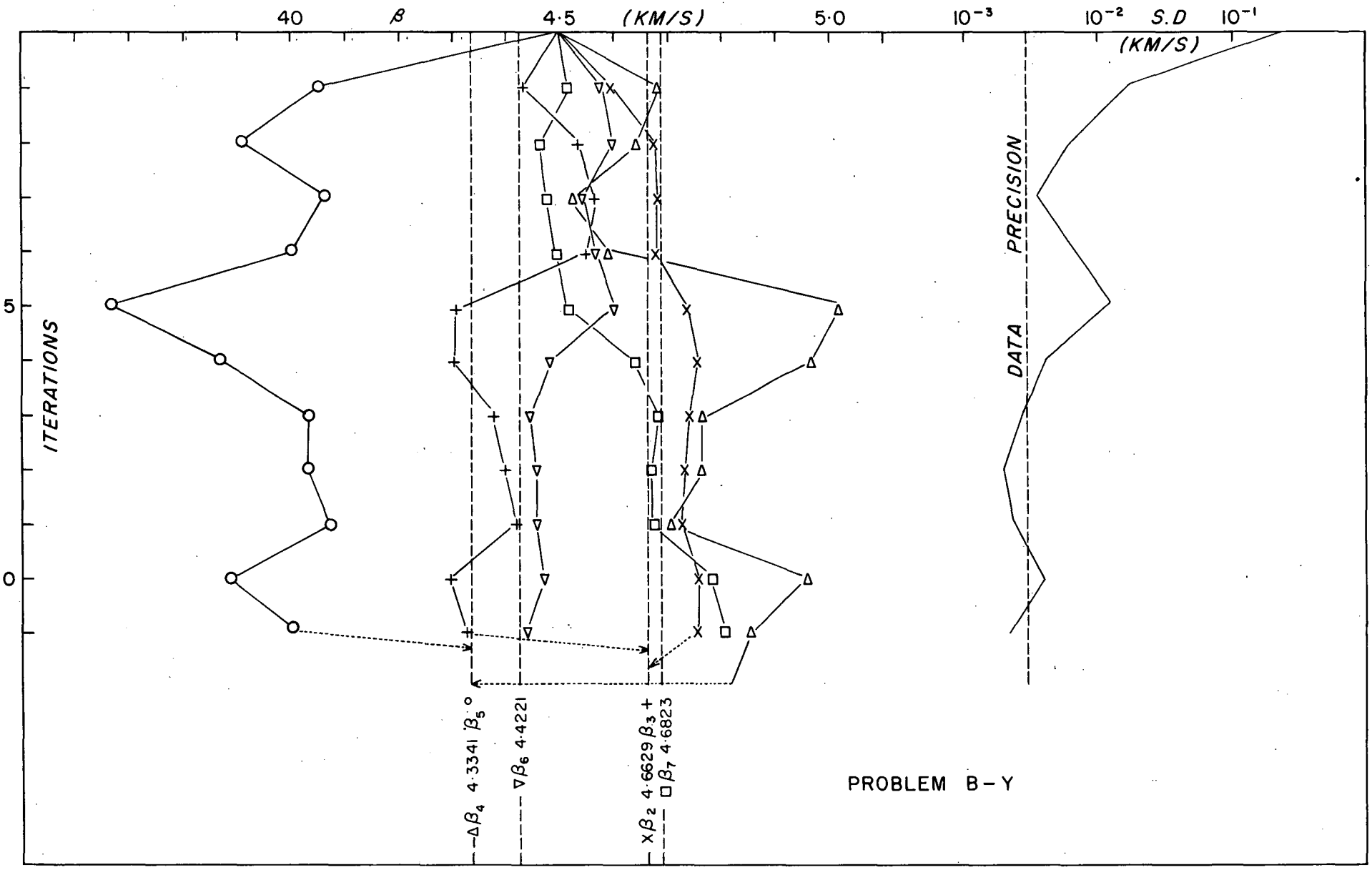

FIG IVC − β NON-CONVERGENT FOR MODEL WITH SPLIT LAYERS AND EXPERIMENTAL DATA OF TWO PLACE ACCURACY. CORRECT VALUES FOR SPLIT LAYER VELOCITIES ARE INDICATED BY ARROWS. S.D. INDICATES NO FURTHER IMPROVEMENT.

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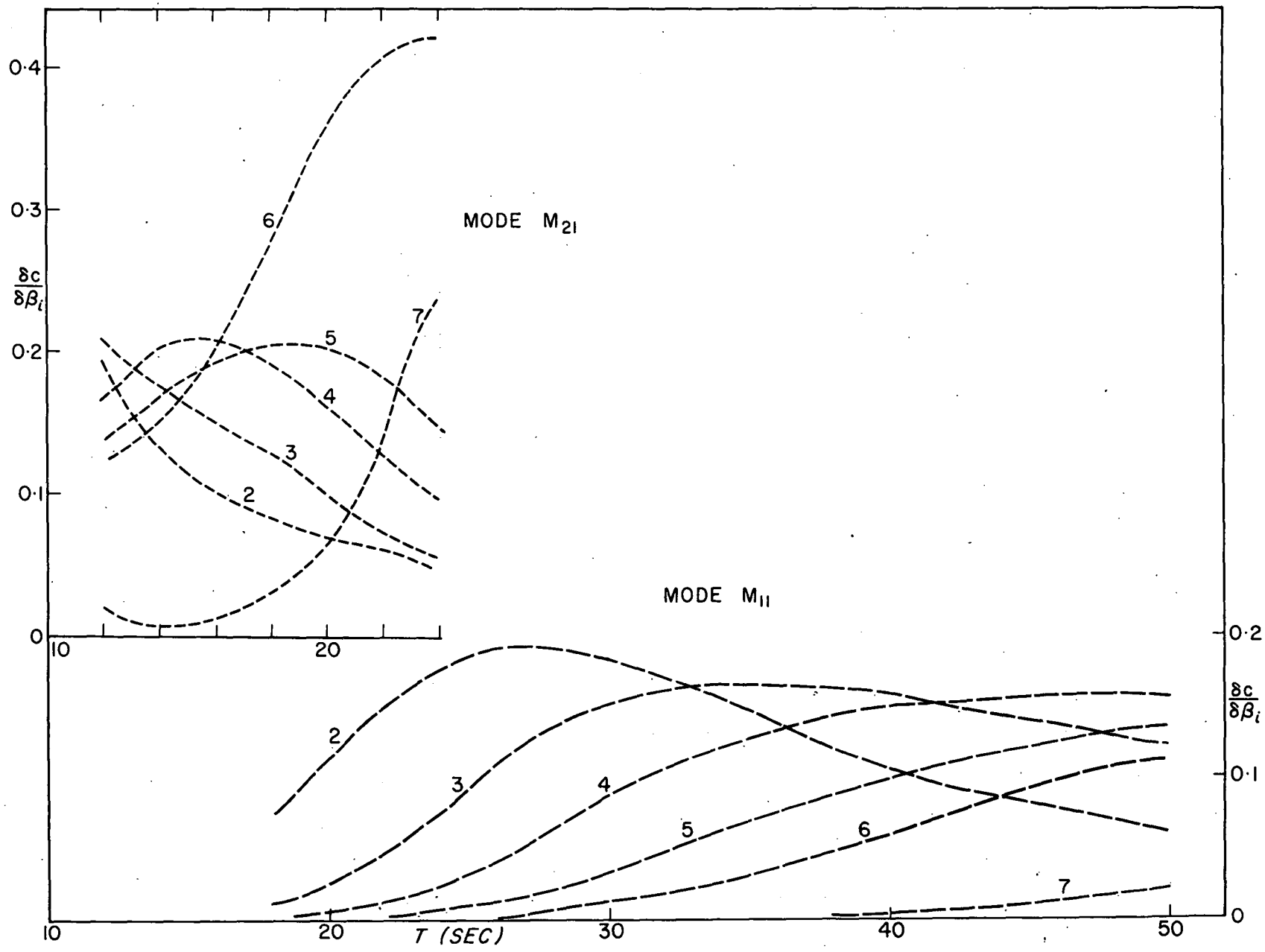

FIG IV D – Partial derivatives, $\delta c/\delta \beta_i$, i = layer number for model Y.

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Table 1

(a) Original Model

Layer No.	Thickness (km)	Compr. Vel. (km/s)	Shear Vel. (km/s)	Density (gr/cc)
1	35	6.10	3.492	2.80
2	40	7.90	4.663	3.32
3	50	7.85	4.334	3.34
4	75	8.00	4.422	3.34
5	-	8.20	4.682	3.36

(b) Model X

1	35	6.10	3.492	2.80
2	40	7.90	4.500	3.32
3	50	7.85	4.500	3.34
4	75	8.00	4.500	3.34
5	-	8.20	4.500	3.36

(c) Model Y

1	35	6.10	3.492	2.80
2	20	7.90	4.500	3.32
3	20	7.90	4.500	3.32
4	25	7.85	4.500	3.34
5	25	7.85	4.500	3.34
6	75	8.00	4.500	3.34
7	-	8.20	4.500	3.36

Table 2

Model Phase Velocities

Period (sec.)	Mode No.	Phase Velocity (km/sec) Set A	Set B
50	1	3.98199	3.98
46	1	3.96719	3.97
42	1	3.94877	3.95
38	1	3.92329	3.92
34	1	3.88428	3.88
30	1	3.81999	3.82
26	1	3.71374	3.71
22	1	3.56225	3.56
18	1	3.40514	3.41
24	2	4.66293	4.66
22	2	4.62337	4.62
20	2	4.58471	4.58
18	2	4.54964	4.55
16	2	4.51958	4.52
14	2	4.49340	4.49
12	2	4.46429	4.46

APPENDIX V

SEISMIC WAVE VELOCITIES IN THE NEW GUINEA - SOLOMON ISLANDS REGION

Reprinted from "CRUST OF THE PACIFIC BASIN"

GEOPHYSICAL MONOGRAPH No. 6

1962

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Seismic Wave Velocities in the New Guinea–Solomon Islands Region

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Abstract—Independent values of the velocity of P waves have been determined to a depth of 500 km below the New Guinea—Solomon Islands region from an empirical study of the arrival times at the surface from 185 earthquakes. The existence of a low-velocity channel with an axis at a depth of 150 km where P waves may be transmitted at a velocity of 7.6 km/sec, is inferred.

The use of preliminary earthquake epicenters, origin times, and depths of the United States Coast and Geodetic Survey (USCGS), has confirmed the greater reliability of such data since these were determined by electronic computer.

Introduction—The velocity distribution of both P and S waves, particularly in the upper 500 km of the Earth's mantle, is a fundamental seismological problem. Its solution has been complicated by suggestions of the existence of a low-velocity channel in the upper mantle [*Gutenberg* 1948, 1953, 1959ab, and later studies of surface-wave dispersion by many authors]. In the upper part of the mantle, where earthquakes occur, velocity variations with depth can be studied by direct observation of P and S wave arrival times.

Although the area of the Pacific which contains the arcuate structures of New Guinea, New Britain, and the Solomon Islands (Fig. 1) is one of the most active seismic areas of the world, there has been little opportunity for a detailed study to be made of its seismicity and tectonic features, as revealed by seismological records, due to a lack of local seismic stations. Those now operating in the area (Fig. 2) are Rabaul (commenced in 1939), Chartres Towers (1957), Port Moresby (1958), Honiara (1960), and Darwin (1961). Even so, the station density over an area 35° of longitude by 10° of latitude is still inadequate and offers only limited scope for quantitative examination by seismological methods of any physical characteristics of the area, particularly in view of the very limited potential of the instrumentation available at any of the above stations.

Nevertheless, sufficient data have accumulated from recordings of earthquakes which occurred in the area between July 1960 and May 1961 (Fig. 2) to allow investigation of the velocity depth relationship for P waves. This has been facilitated by the high frequency of earthquake occurrence, together with a very wide range of focal depths encountered in the area.

Relative seismicity is not necessarily indicated by Fig. 2 for different areas as no account is taken of earthquake magnitude, and the period of observation is extremely short.

Observational data—The observational data used in this investigation are conveniently summarised in the form of a series of graphs showing travel time as a function of distance (Fig. 3). These were plotted from P-wave arrival times listed in preliminary station bulletins together with pertinent data extracted from USCGS Preliminary Determination of Epicenter cards which were compiled using an IBM 650 program as from July 1960. Epicentral distances were individually calculated using direction cosines. Because of the high frequency of occurrence, it has been possible to group 185 shocks, having focal depths from 13 to 516 km, into ten depth ranges. By using results from four stations, the epicentral distance range 0–25° (over which the form of the curve, arrival time against distance, must be ascertained) has been covered for each group of shocks.

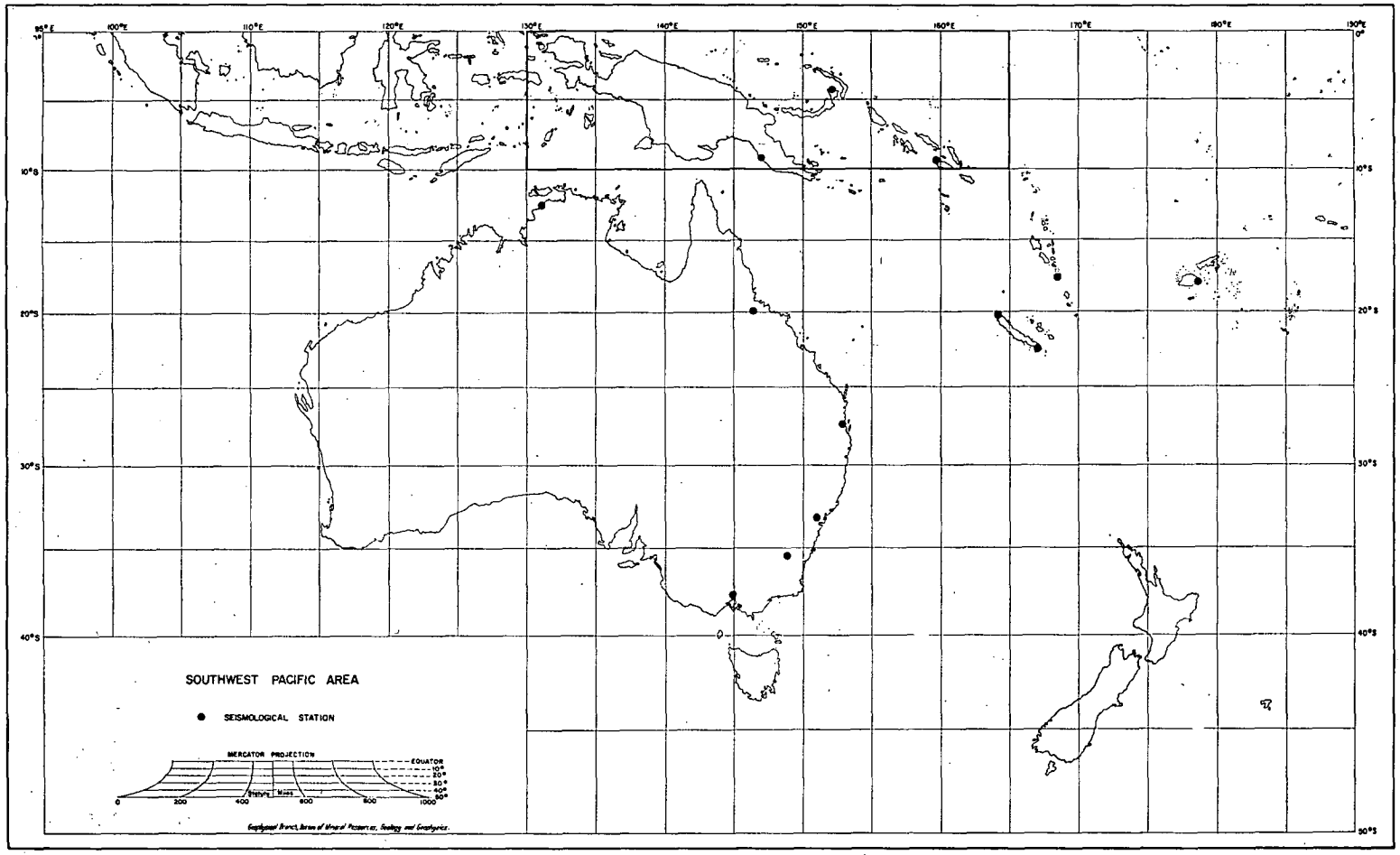

FIG. 1—Southwest Pacific area showing New Guinea—Solomon Islands region

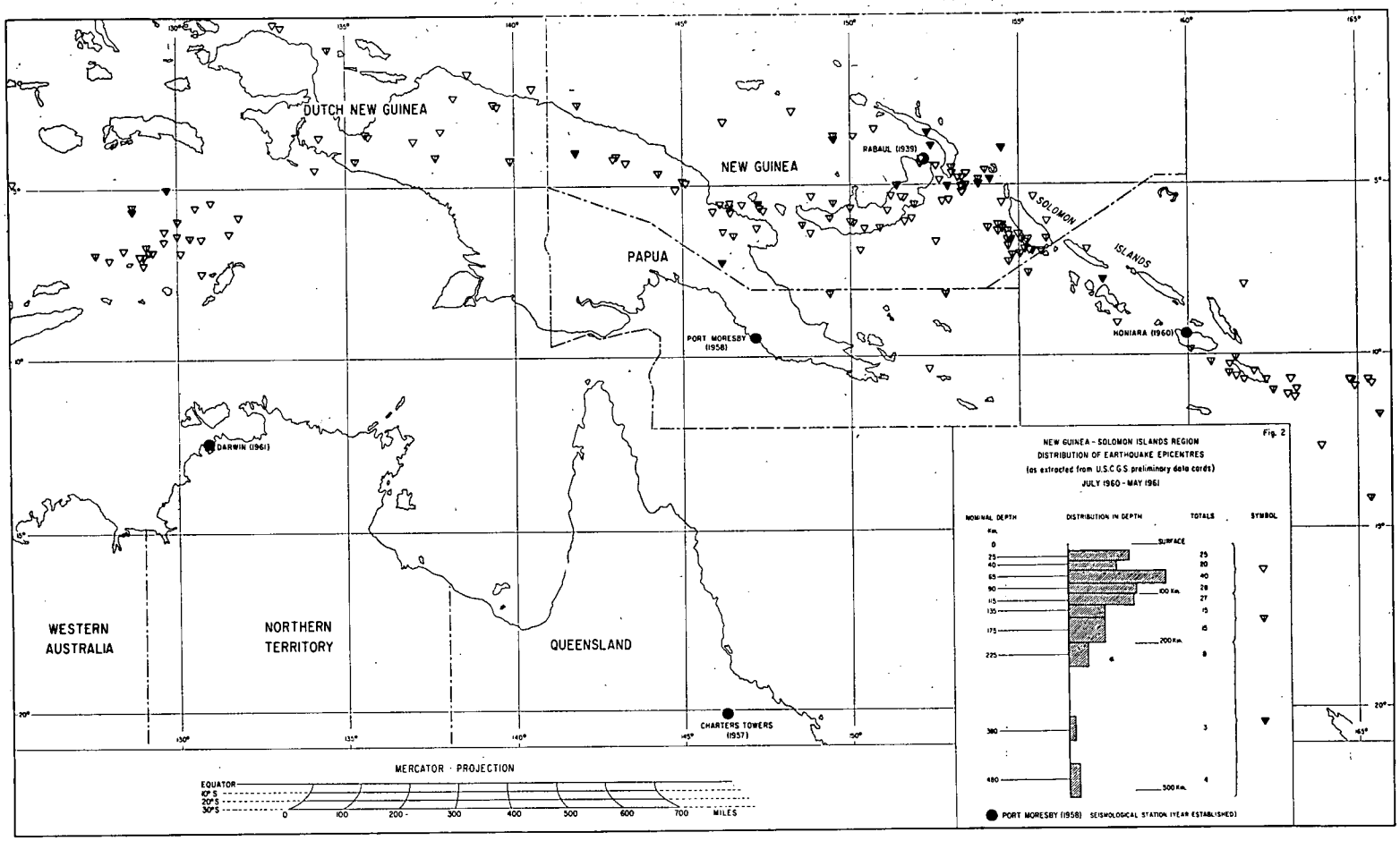

FIG. 2—Distribution of earthquake epicenters July 1960–May 1961

The graphs use a vertical scale of the form $t - k\triangle$, to accentuate the change in slope of the travel-time curve on each side of the point of inflection, and this allows a more accurate interpretation to be made of the slope of the adopted curve at this point. The value of k is chosen so that the portion of the travel time curve in the vicinity of the point of inflection,

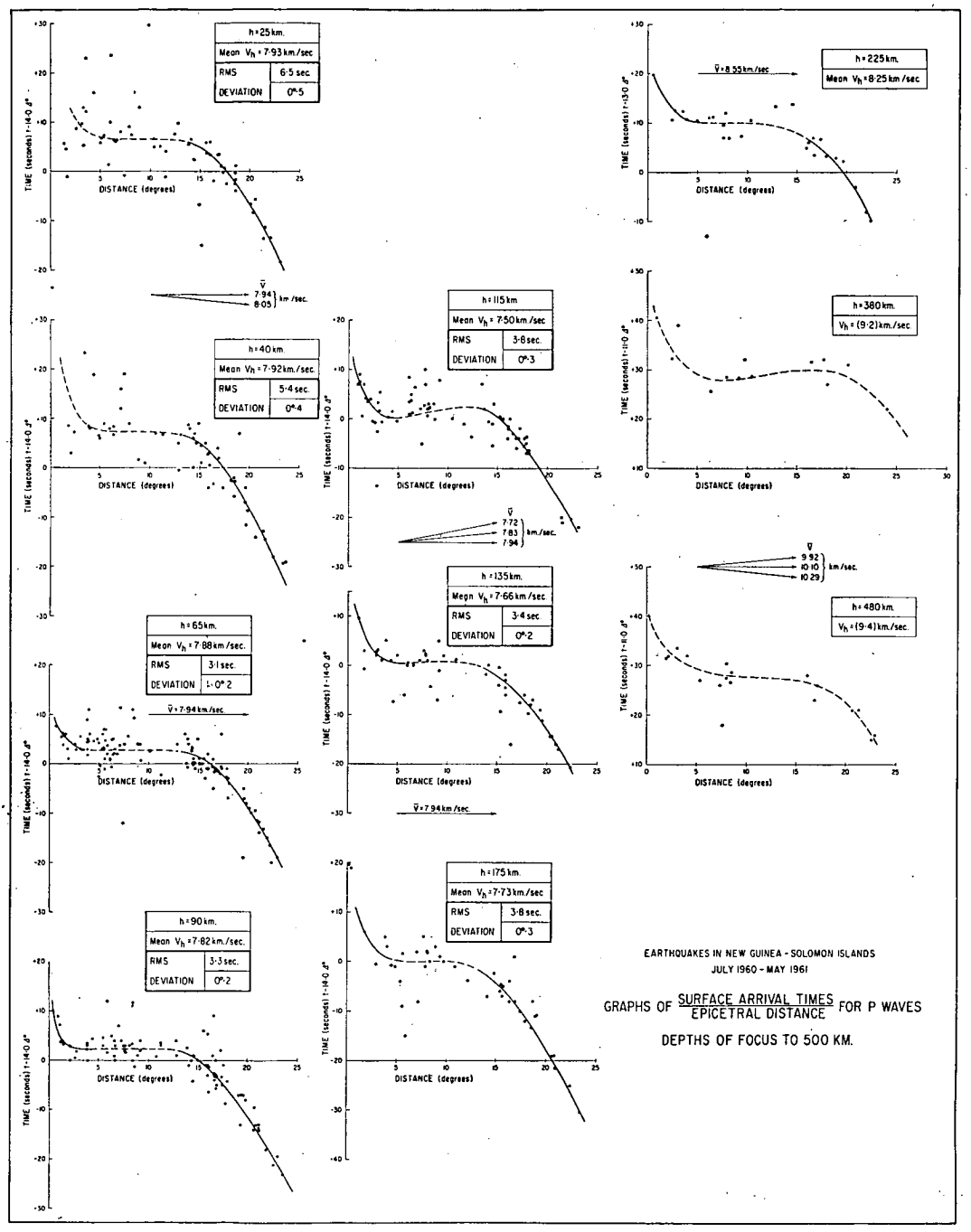

FIG. 3—P-wave travel-time curves

is nearly horizontal. For this investigation, data relating to all earthquakes, regardless of magnitude, listed on the USCGS cards, have been given equal weight.

Some uncertainty is involved in assessing a curve of best fit for each group of plotted points (travel-time curve) but it is assisted by the fact that the two shoulders of each graph, for example the $h = 65$ km graph, are in general more clearly defined than the central section and thus give a guide to the limits of slope of the critical center section (that contains the point of inflection). To minimize errors in such interpretation, each group of points was plotted three times, using a slightly different value of k in the y-axis scale in each case to ensure a variation in the relative positions of these shoulders. The resulting three velocity values agreed to within 0.1 km/sec for most groups (Table 1).

Interpretation—A method first suggested by *Gutenberg* [1953] has been applied to deduce values of velocity at the nominal depths representing each group of shocks. Its validity depends (1) on the ray theory to explain the propagation of energy from earthquake foci, (2) on the fact that the wave velocity is a function of focal depth, but remains constant in the horizontal plane at a given depth, and (3) on the continuity of the travel-time curve observed at the surface over the range of epicentral distances considered, at least as far as its point of inflection.

Briefly, Gutenberg showed that under these conditions the velocity of P or S waves at depth h,(V_h), is simply related to the minimum value of the apparent velocity, V_{min}, observed at the surface

$$V_h = \bar{V}_{min}\, r_h/r_o$$

where r_h = Earth radius at depth h, and r_o = Earth radius (6378 km).

He determined a velocity-depth relationship for both P and S waves by examining the reported arrival times at a large number of stations in each case, for about 80 earthquakes of varying focal depths.

In the current investigation, Gutenberg's method has been applied with slight modification to earthquakes in the New Guinea—Solomon Islands Region to determine whether his general results apply to such a restricted area as this. From the mean minimum apparent velocity estimated from the graphs for each nominal depth, the velocity of the ray leaving the focus horizontally, at that depth, has been calculated. The reduced results for P waves are illustrated by Fig. 4 and those for S waves by Fig. 5. The latter are presented for the sake of completeness only and are considered much less reliable than the P-wave velocities.

In Figs. 4 and 5, a comparison is made between the velocity distribution inferred for the New Guinea region and distributions suggested by *Bullen* [1953, p. 211] and *Gutenberg* [1953]. A comparison is also made between

TABLE 1—*Velocity of P waves, variation with depth, New Guinea-Solomon Islands region*

Depth range	Nominal depth	$\bar{V}_{min}$ $k = 14.0$	$\bar{V}_{min}$ $k = 14.2$	$\bar{V}_{min}$ $k = 14.4$	Mean $\bar{v}_{min}$	$\frac{r}{R}$	V_h	Number of Obs.	RMS deviation	
km	km	km/sec	km/sec	km/sec	km/sec		km/sec		sec	°
0–31	25	7.97	7.94	7.92	7.95	.998	7.93	67	6.5	0.5
32–49	40	8.01	7.94	7.96	7.97	.994	7.92	59	5.4	0.4
50–79	65	7.94	7.94	8.00	7.96	.990	7.88	113	3.0	0.2
80–101	90	7.94	7.90	7.96	7.93	.986	7.82	74	3.3	0.2
102–125	115	7.7	7.7	7.5	7.6	.982	7.5	69	3.4	0.2
126–150	135	7.83	7.83	7.79	7.82	.979	7.66	48	3.4	0.2
151–199	175	7.94	8.00	7.88	7.94	.973	7.73	45	3.8	0.3
		$k = 13.0$								
200–250	225	8.55			8.55	.965	8.25	28	2.0	0.1
		$k = 11.0$								
350–410	380	(9.8)			(9.8)	.94	(9.2)	13		
450–520	480	(10.2)			(10.2)	.92	(9.4)	17		

Note: Parentheses indicate less reliable values because of paucity of data.

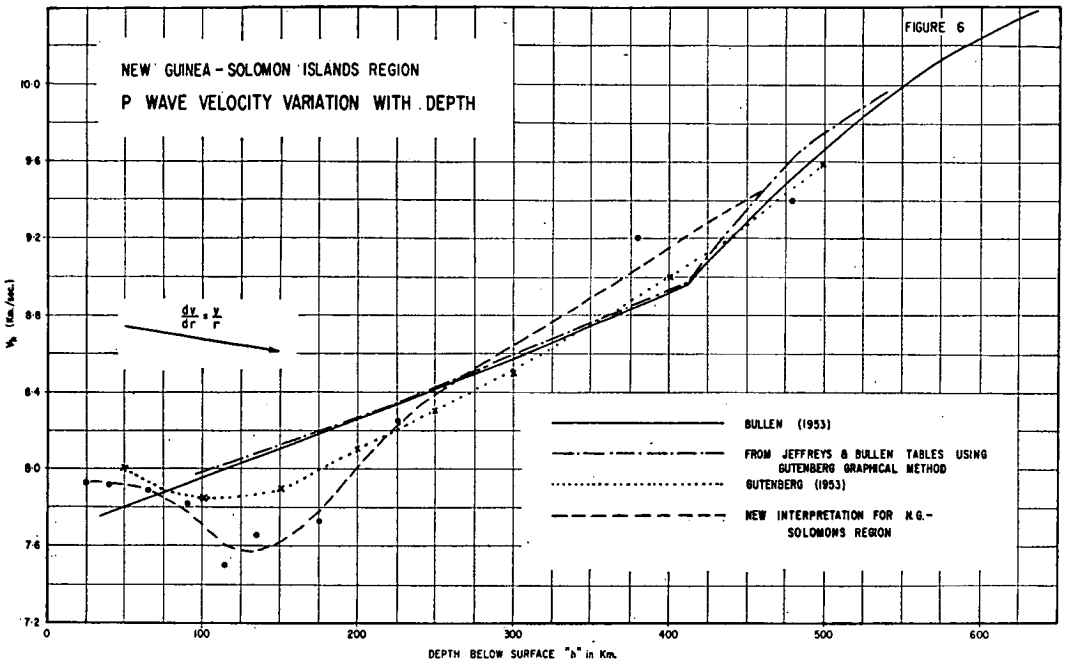

FIG. 4—Velocity of P waves as a function of depth

Bullen's theoretically determined velocity distribution and that obtained by treating the standard JB [*Jeffreys* and *Bullen*, 1948] tables as a series of actual observations and computing a velocity distribution using the graphical method described above.

Discussion—The data representing only P wave arrivals will be discussed because it is more comprehensive and therefore more reliably interpreted than that for S waves.

It appears (Fig. 4) that the region of low velocity in the New Guinea—Solomons area may be thicker and have a lower minimum value of velocity (which is reached at a greater depth) than found by Gutenberg. Also, it may be noted that the rate of decrease in velocity is greatest for the depth range 75–150 km and exceeds the critical rate, of 0.1 km/sec per 100 km depth (given by V/r), which is sufficient to cause a ray entering such a region to be refracted downwards (that is, with a radius of curvature less than the radius of that depth). A shadow zone could thus be produced at the surface, and consequently, a discontinuous travel-time curve having two branches [*Bullen*, 1953, pp. 109–120; *Gutenberg*, 1959ab]. It is therefore probable that the inflection points (corresponding to $\bar{V}_{min}$) on the 90, 115, 135 km graphs lie in shadow zones and the values of $\bar{V}_{min}$ are in fact interpolated. Nevertheless the resulting values, V_h, should still be close to the actual value of velocity at the depth concerned [*Gutenberg* 1959b, p. 442]. Certainly it is difficult to concede that V_h values would be much higher as the outer sections of the corresponding travel-time curves would then not fit the observed data.

Gutenberg's method of analysis allows V_h values at different depths to be derived independently of each other. This is an advantage over the classical theoretical method of determination [*Bullen*, 1953, pp. 109–120; 1956, p. 99] which requires that the travel-time curve be continuous over the range of epicentral distances covered by the ray paths being analysed. If not, assumptions which may seriously affect the resultant velocities obtained for various depths must be made.

However, values of V_h here obtained are subject to error which may be caused by a number of factors, the most important being (a) errors of interpretation of the form of the adopted travel-time curve due to the scatter of plotted points; (b) errors in the determination of $\bar{V}_{min}$

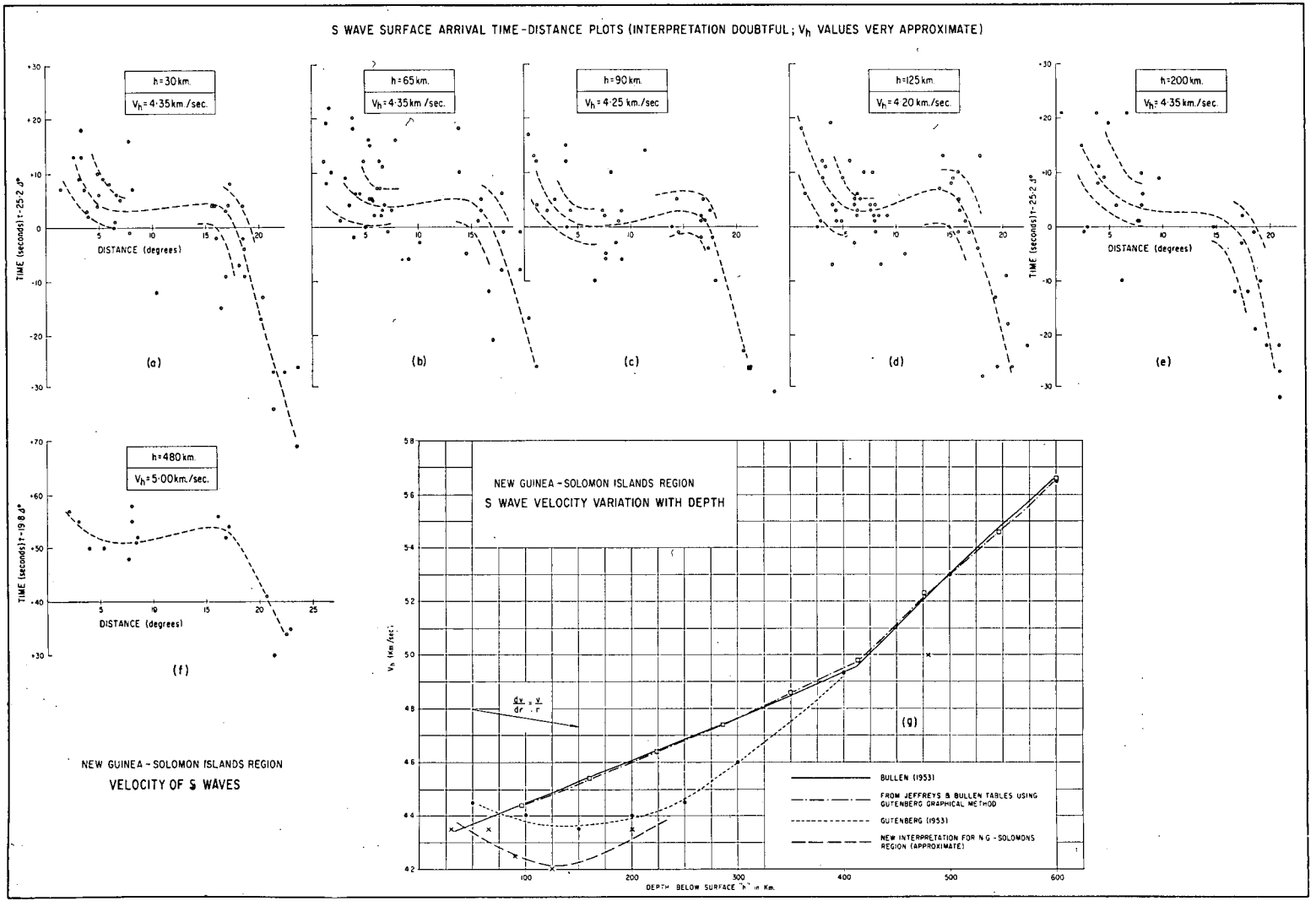

FIG. 5—Velocity of S waves as a function of depth, and travel-time curves

at distances where there are no first arrivals, owing to the presence of a shadow zone. These would be caused by the condition $dV/dr \geq V/r$ in the low-velocity channel.

Quantitative estimates of the accuracy of V_h values cannot be made at this stage other than the indications given by Table 1. The values depend entirely on the graphical interpretations in Fig. 3 and the minimum velocity inferred may in fact be somewhat higher. However, it would be difficult to reconcile a velocity distribution having no diminution with depth, with the observed data.

It is suggested that these data do, at least, imply the existence of a low-velocity channel such that the maximum velocity gradient (dV/dr) between 0 and 150 km is not very much less than V/r, if it does not in fact exceed V/r. If $dV/dr < V/r$, errors of type (b) above would not be expected and continuity of the travel-time curves (Fig. 3) leading to more reliable interpretation of V_h, could then be inferred.

Therefore it is considered that the data summarised in Fig. 4 do suggest the presence of a low-velocity channel and a velocity distribution at variance with the relationships found by other investigators. It is interesting to speculate that this difference may be caused by a feature or conditions peculiar to the New Guinea—Solomon Islands region.

A rather novel means of estimating the accuracy of the USCGS epicenter determinations is provided by the graphs of Fig. 3. It is usual to find considerable scatter in any such set of observations consisting of preliminary data. Estimates have been made of the RMS deviation of the plotted points vertically displaced from the adopted travel-time curves (Fig. 3; Table 1). It is found to be highest for the 25 km and 40 km groups of shocks and roughly constant thereafter, with a small increase for the 115, 135, and 175 km graphs. Three causes of this scatter are suggested: (1) Errors in the calculated epicentral distances which will be transferred to the graph by the k factor in the vertical scale. Such errors would produce a random scatter. (2) Incorrectly identified P onsets which in most cases would be late, not early, and which would cause a scatter predominantly in a positive vertical direction. (3) Definite initial onsets which do not represent the arrival of the direct wave, for instance, at a station within the shadow zone for a particular shock, would again cause a predominantly positive vertical scatter in the middle portion of the graph.

As the average difference between computed and observed arrival times for shocks in all depth ranges is only about 1½ sec, it is suggested that errors in epicentral distance may therefore be the main cause. If so, the RMS values indicate an equivalent mean error of between 0°.2 and 0°.3 for most depths which seems surprisingly small for preliminary epicenter determinations. Nevertheless, it is clear from the appearance of the graphs that extreme difficulty would have been experienced in fitting the curve to each set of points had the scatter been much greater than this value.

At depths less than 50 km, the second assumption, namely that there are no significant horizontal variations of velocity, would be violated if the complex tectonics of the area extend well into this depth range. Moreover, any shocks in the 25-km group having epicenters above the Moho discontinuity will lie in a region where wave velocities are lower and possibly vary widely. These conditions would lead to additional scatter.

Below 50 km, the scatter is roughly the same in each graph but a small increase occurs for shocks between 100 and 200 km depth. Referring to Fig. 4, it will be noted that the variation between any of the previously published velocity-depth curves and the curve determined in this investigation is greatest for this depth range. Many earthquakes used for this study were small and the corresponding epicenter data was consequently available only from the closest stations. The increased scatter noted may be due to errors in distance calculated from epicenters determined using standard travel time data, if these are incorrect for this region.

Conclusions—Evidence to support the contention that a region of low velocity for seismic waves exists under the New Guinea–Solomon Islands area has been presented. The minimum velocity reached may be as low as 7.6 km/sec at a depth of about 150 km. The decrease in velocity found is much more pronounced than hitherto reported and suggests that shadow zones for the arrival of direct P waves exist in the area.

The successful use of USCGS preliminary epicenter data is demonstrated, and the average error in epicentral positions, determined for earthquakes in the New Guinea–Solomon Islands region since July 1960 by computer methods, appears to be about ¼°. This is a favorable comment on the overall accuracy of such data.

Improvement in the quality of this kind of data will be possible in due course through more selective use of earthquakes, and by distinguishing between different ray paths from a regional geological standpoint. This was not possible in the present preliminary investigation. The number of events available was too limited to permit more than a general analysis, which at the same time did provide some empirical evidence of the accuracy of the USCGS IBM epicenter determination program.

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APPENDIX VI

INSTRUMENTAL RESPONSE

Throughout this investigation it was important to ascertain the phase response of recording equipment (Fig. VI A) over the frequency range 0.2 to 0.01 cycles/sec. Precision was generally better than ± 0.5 sec., corresponding to ± $1^{o}.8$ at 100 sec. period and ± 36^{o} at 5 sec. period.

The principal causes of drift in the transfer function were -

(i) Variations, due to temperature fluctuations, in seismometer free period with change in boom position. This could be maintained only within ± 1 sec. due to faulty construction of the seismometer.

(ii) Variations of damping coefficient from 0.7 to 1.4.

(iii) Variable settings of a phase control resistor (R_1 Fig. VI B) within the recorder filter system.

Three calibration techniques were employed to evaluate the transfer function.

Method A

Transient calibration using a voltage step into the seismometer calibration coil i.e. a "voltage acceleration" step. The Fourier transform of the resulting response was evaluated by digital methods.

Method B

Steady state calibration using a function generator. This was employed only occasionally to check the response in the field where no means existed to apply Method A.

Method C

Theoretical computation of response and transfer function using seismometer constants and filter component values.

There is little unconventional content involved and descriptions are accordingly brief.

Results from Method A were used in all computations of phase velocities where the short period end of the range exceeded 10 sec. This

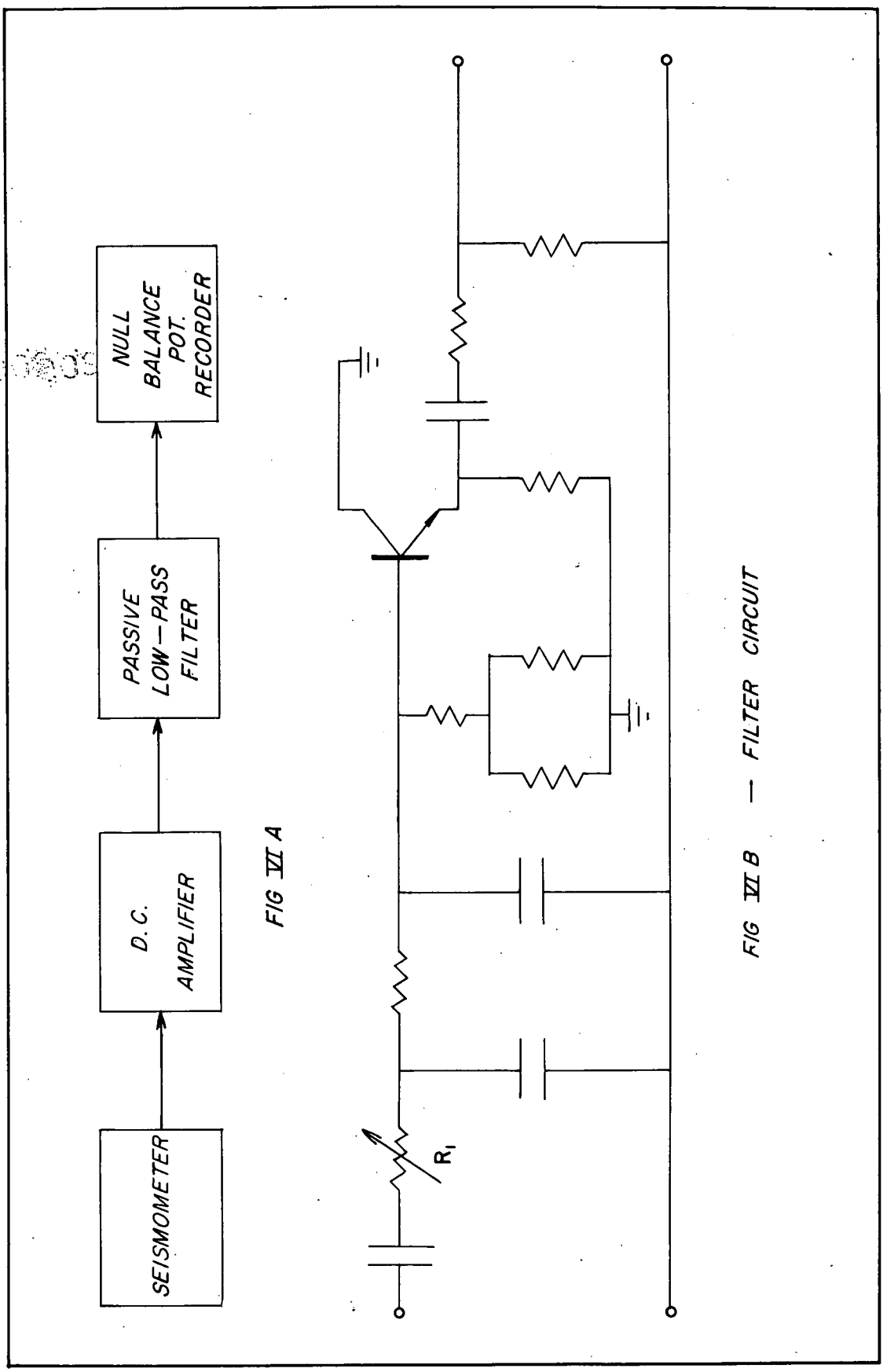

FIG VII A

FIG VII B — FILTER CIRCUIT

applied to all fundamental mode computations. For the higher modes, where most of the period range was less than 15 seconds, a transient step response was computed theoretically at 1 second intervals using Method C. This provided standard input data for the analysis program described in Chapter II, which employed Method A.

METHOD A

The transient calibration technique is described by Espinosa et al (1962). Routine field procedures included daily recording of the step function response. This was digitised at 1 sec. intervals on those records which contained seismic events for analysis.

The Fourier transform of the step response was evaluated by first expanding it into a series of Laguerre functions. These have been shown by Ward (1954) to be ideally suited for approximating the step response of dynamic systems. Dean (1964) summarised the key relations involved and outlined the appropriate digital technique.

Laguerre functions are suitable because -

(a) like transient response functions they are decaying exponentials, orthogonal over the time range $0 \leq t \leq \infty$, and zero outside it. A series should therefore converge fairly quickly; and

(b) the Fourier transforms of Laguerre functions are defined for all frequencies, and thus allow the instrumental transfer characteristics to be determined at any frequency without resorting to interpolatory numerical integration routines.

Notation:

The n^{th} Laguerre polynomial $la_n(t) = \sum_{k=0}^{n} \binom{n}{k} \frac{(-t)^k}{k!}$ . . . . . (1)

The n^{th} Laguerre function: $l_n(t) = e^{-t/2} la_n(t)$ . . . . . (2)

$L_n(\omega)$: The Fourier transform of $l_n(t)$

$F(\omega)$: The Fourier transform of $f(t)$, the step response of the system.

$p \equiv i\omega$ (Laplace transform notation)

α : A time scaling factor

$\mathcal{L}[\ell_n(t)]$: The Laplace transform of $\ell_n(t) = L_n(p)$

Recurrence Relations:

$$n\ell_n(t) = (2n-1)\ell_{n-1}(t) - (n-1)\ell_{n-2}(t) \qquad \ldots\ldots (3)$$

$$t\ell_n'(t) = (n - \tfrac{t}{2})\ell_n(t) - n\ell_{n-1}(t)$$

Frequency Response (Ward, 1954):

$$\mathcal{L}[la_n(t)] = \frac{1}{p}\left\{\frac{p-1}{p}\right\}^n$$

$$\mathcal{L}[e^{-ht} la_n(t)] = \frac{1}{p+h}\left(\frac{p+h-1}{p+h}\right)^n$$

$$\mathcal{L}[\ell_n(t)] = (p-\tfrac{1}{2})^n / (p+\tfrac{1}{2})^{n+1} \qquad \ldots\ldots (4)$$

Analogue applications are apparent from (4). The frequency response of $l_n(t)$ can be represented by a series of cascaded networks, the first having the response $\frac{1}{p+\frac{1}{2}}$ and successive stages $\frac{p-\frac{1}{2}}{p+\frac{1}{2}}$ as illustrated for example by Lee (1932), Lampard (1955), Flinn & Dean (1964).

Introducing the scaling factor α, it follows that $\frac{1}{\alpha} L_n\left(\frac{p}{\alpha}\right)$ is the transform of $l_n(\alpha t)$. Normalisation of these functions is preserved regardless of time and frequency scaling factors by multiplying both functions by $\sqrt{\alpha}$. Thus from (2) and (4),

$$\sqrt{\alpha}\,\ell_n(\alpha t) = \sqrt{\alpha}\, e^{-\alpha t/2} la_n(\alpha t)$$

$$\frac{1}{\sqrt{\alpha}} L_n\left(\frac{p}{\alpha}\right) = \sqrt{\alpha}\,(p-\alpha/2)^n / (p+\alpha/2)^{n+1} \qquad \ldots\ldots (5)$$

$$= \frac{(-1)^n \sqrt{\alpha}\, e^{-i(2n+1)\phi}}{\sqrt{(\alpha/2)^2 + \omega^2}} \qquad \text{, where } \phi = \tan^{-1}(2\omega/\alpha)$$

$$\ldots\ldots (6)$$

Orthogonality (Flinn & Dean 1964):

$$\text{In time } \int_0^\infty \ell_n(t)\,\ell_m(t)\,dt = 0 \quad , m \neq n$$

$$= 1 \quad , m = n$$

In frequency

$$\frac{1}{2\pi}\int_{-\infty}^{\infty} L_m(i\omega)\cdot\overline{L_n(i\omega)}\,d\omega = 0,\ m\neq n$$
$$= 1,\ m=n.$$

where the bar symbol indicates a complex conjugate.

Time Scaling and Convergence:

Ward (1954) showed that singly resonant systems converge fastest. He related the resonant frequency ω_o, to the time scaling factor, α, and showed that a condition for minimising c_{N-1}, the co-efficient of the final term in a series, is that the real and imaginary parts of the transform should be equal at $\omega = \omega_o$.

i.e. From equation (6) $\omega = \frac{\alpha}{2}\tan\frac{n\pi}{2N}$ $\qquad n = 0, 1, 2 \ldots, N$

at $\omega = \omega_o$, $\omega_o = \frac{\alpha}{2}$

(Flinn and Dean 1964) . . . . . (7)

Expansion of the Transient f(t):

We seek co-efficients c_k such that $f(t) = \sum_{k=0}^{\infty} c_k \ell_k(t)$ . . (8)

where $c_k = \int_0^{\infty} f(t)\, l_k(t)\, dt$.

Using the Gaussian quadrature technique (Lanczos 1967, pp 396-412)

$$\int_0^{\infty} f(t)\, l_k(t)\, dt \approx \sum_{i=1}^{N} A_i\, f(t_i)\, l_k(t_i),\quad k = 0, \ldots, N-1 \quad . (9)$$

where t_i, are the zeros of $l_N(t)$ and $A_i = \dfrac{t_i}{[N\ell_{N-1}(t_i)]^2}$

(Flinn and Dean 1964)

The values A_i are the weight factors for the Nth Laguerre function.

Programming:

Flinn & Dean (1964) have tabulated, to double precision, values of t_i, A_i, and $A_i e^{t_i}$ for all Laguerre functions of zero order up to N = 100. These data were employed to single precision, in formula (9) programmed to evaluate the c_k's.

The values of f(t) were found by interpolation between equally spaced values of the step response trace digitised at 1 sec. intervals.

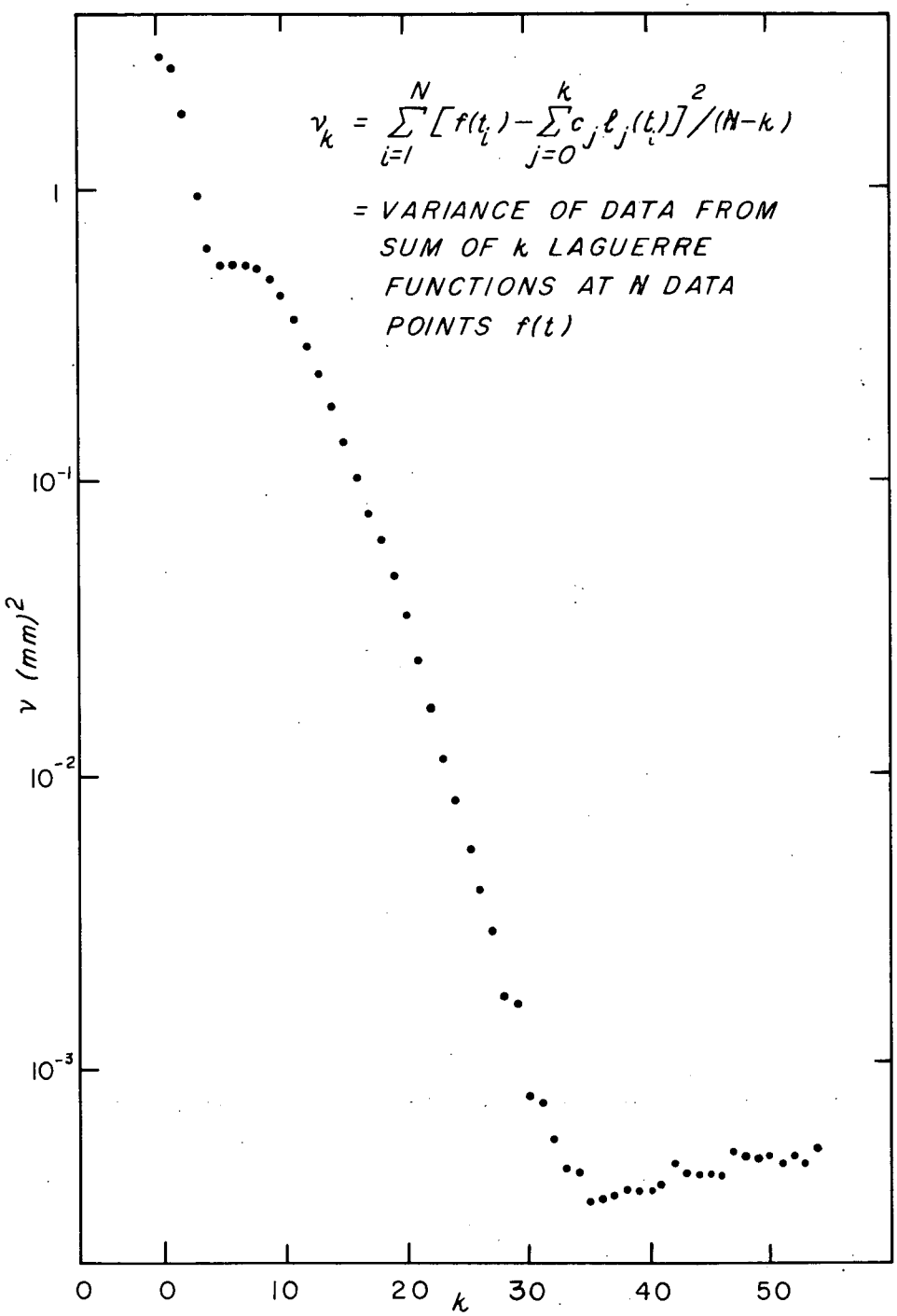

FIG. VI C CONVERGENCE OF LAGUERRE EXPANSION HAVING k TERMS, OF STEP RESPONSE TRANSIENT.

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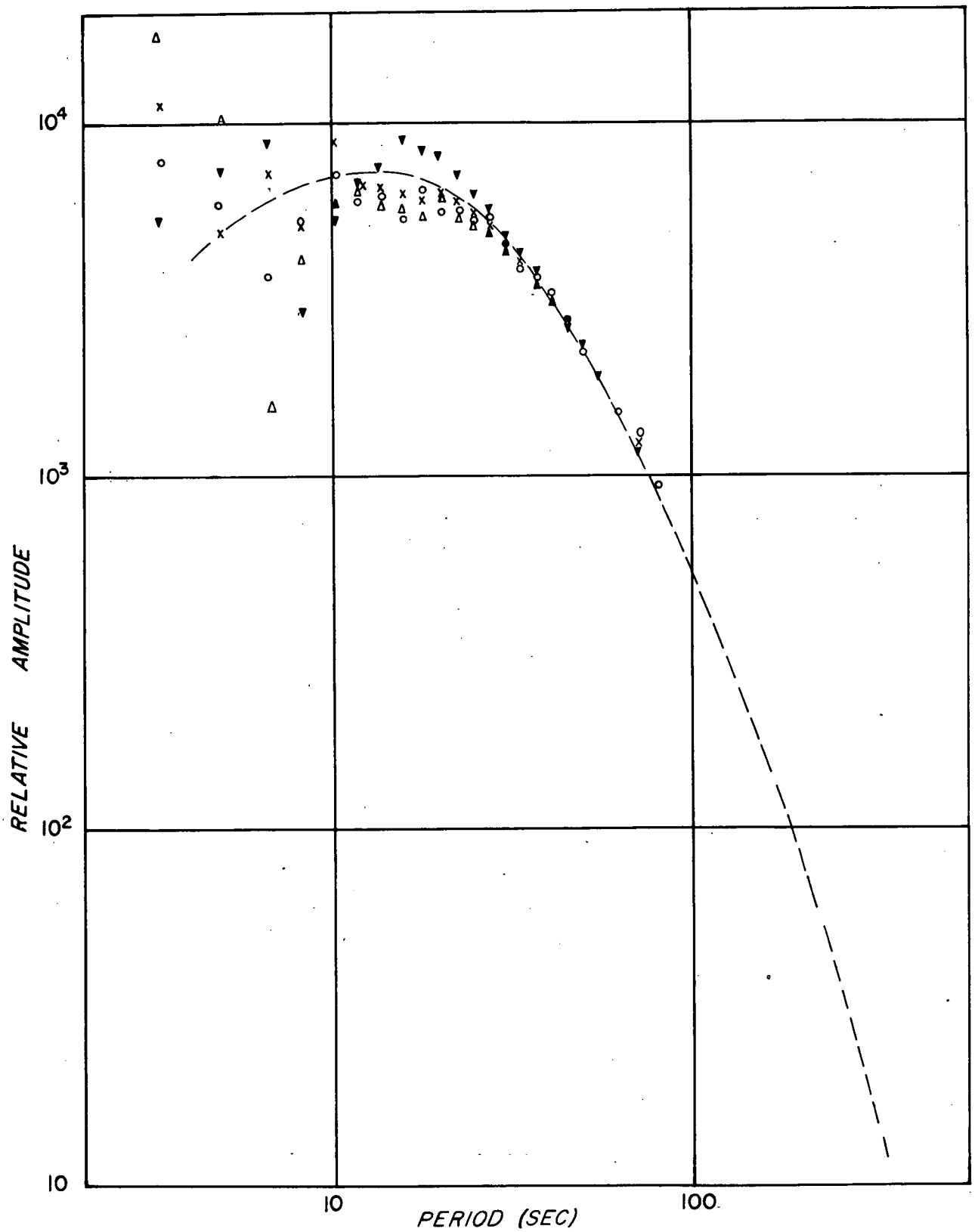

FIG VI D RELATIVE AMPLITUDE TRANSFORMS, METHODS A AND C. FOUR DETERMINATIONS SHOWN FOR METHOD A. METHOD C: T_o= 15 secs, R, = 75K, B_o= 1·0

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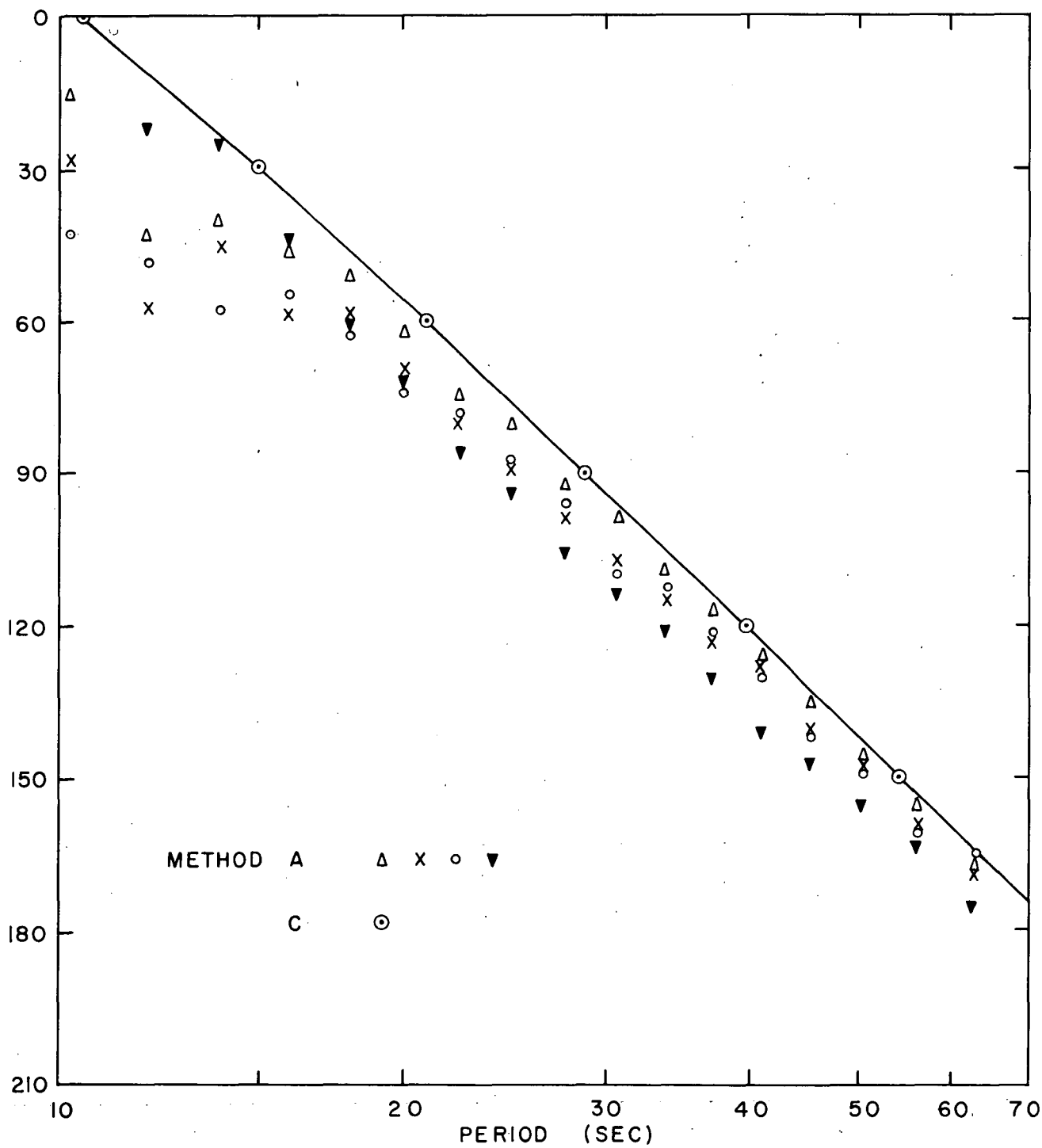

FIG. VI E PHASE TRANSFORMS, METHODS A, C.
FOUR DETERMINATIONS ARE SHOWN FOR METHOD A.
METHOD C : T_o = 15 SEC, R_1 = 75 K, β_o = 1·0.

The degree of polynomial, N, was estimated from an approximate knowledge of ω_o of the system, allowing α to be determined from (7), whence $\alpha t_N = T$, where T = data length. Flinn and Dean (1964) have demonstrated that provided α is within a factor of 2 of its correct value, reasonably satisfactory convergence will occur. The transform was evaluated using equation (6). About sixty digitised transients were processed during the investigation.

Result:

Fig. VI C indicates the accuracy, in time, of expanding f(t) by this method.

$f_{1_k}(t) = \sum_{j=0}^{k} c_j \ell_j(\alpha t)$ $\quad k = 0, 1 \ldots 54$ is a synthetic f(t) evaluated from a finite series of k + 1 terms c.f. equation (8) above.

The variance $\sum [f(t) - f_{1_k}(t)]^2 / (100-k) = v_k$ was computed from 100 equally spaced digitised points and is plotted against k. Clearly, a series of 35 terms adequately represents the data, f(t).

The instrument behaviour is primarily controlled by the acceleration response of the seismometer (a voltage step corresponding to an acceleration step).

Fig. VI D, E shows a typical amplitude and phase transform. Clearly, reliability begins to deteriorate for periods less than the free period, T_o.

As the period decreases the acceleration sensitivity of the seismometer decreases, and both real and imaginary parts of the transform become small. In practice, phase shifts employed for periods less than 10 sec. were computed from a synthetic step response calculated using method C.

METHOD B

Steady State Method:

This involved simply the response of the equipment to a continuous

sine wave input from a function generator. The phase shift was measured directly with respect to a marker pulse superimposed on the input at its peak amplitude.

A Hewlett Packard Function Generator was used for the purpose.

METHOD C

A general program was designed by Brownell (in prep) to compute transfer functions, system response and sensitivity of these to various parameters of a very wide range of electrical and electronic networks. This was employed to analyse the seismic system employed here.

Specifically the program permitted -

(1) Calculation of transfer function at short periods;

(2) Determination of the extent of variations of the transfer functions caused by changes in specified parameters;

(3) Calculation of theoretical transient time response variations;

(4) Calculation of group delay times $\phi'(\omega)$, where $\phi(\omega)$ is the phase transform.

Seismometer Response:

We can derive the frequency response, $F(\omega)$, of the pendulum in the conventional way from the differential equation of motion and express it in polynomial form,

$$\ddot{x} + 2\beta_o\omega_o\dot{x} + \omega_o^2 x = -\lambda\ddot{u} \qquad \ldots\ldots\ldots (10)$$

where $Xe^{i(\omega t+\phi)} = x$, the pendulum motion, β_o = pendulum damping.

$Ue^{i\omega t} = u$ = ground motion, $1/\omega_o$ = pendulum free period,

λ = static magnification

Substituting for x and u, (1) becomes

$$-\omega^2 Xe^{i(\omega t+\phi)} + 2i\beta_o\omega_o Xe^{i(\omega t+\phi)} + \omega_o^2 Xe^{i(\omega t+\phi)} = -\lambda\omega^2 Ue^{i\omega t} = -\lambda i\omega\ddot{u}$$

whence, normalising ($\lambda = 1$),

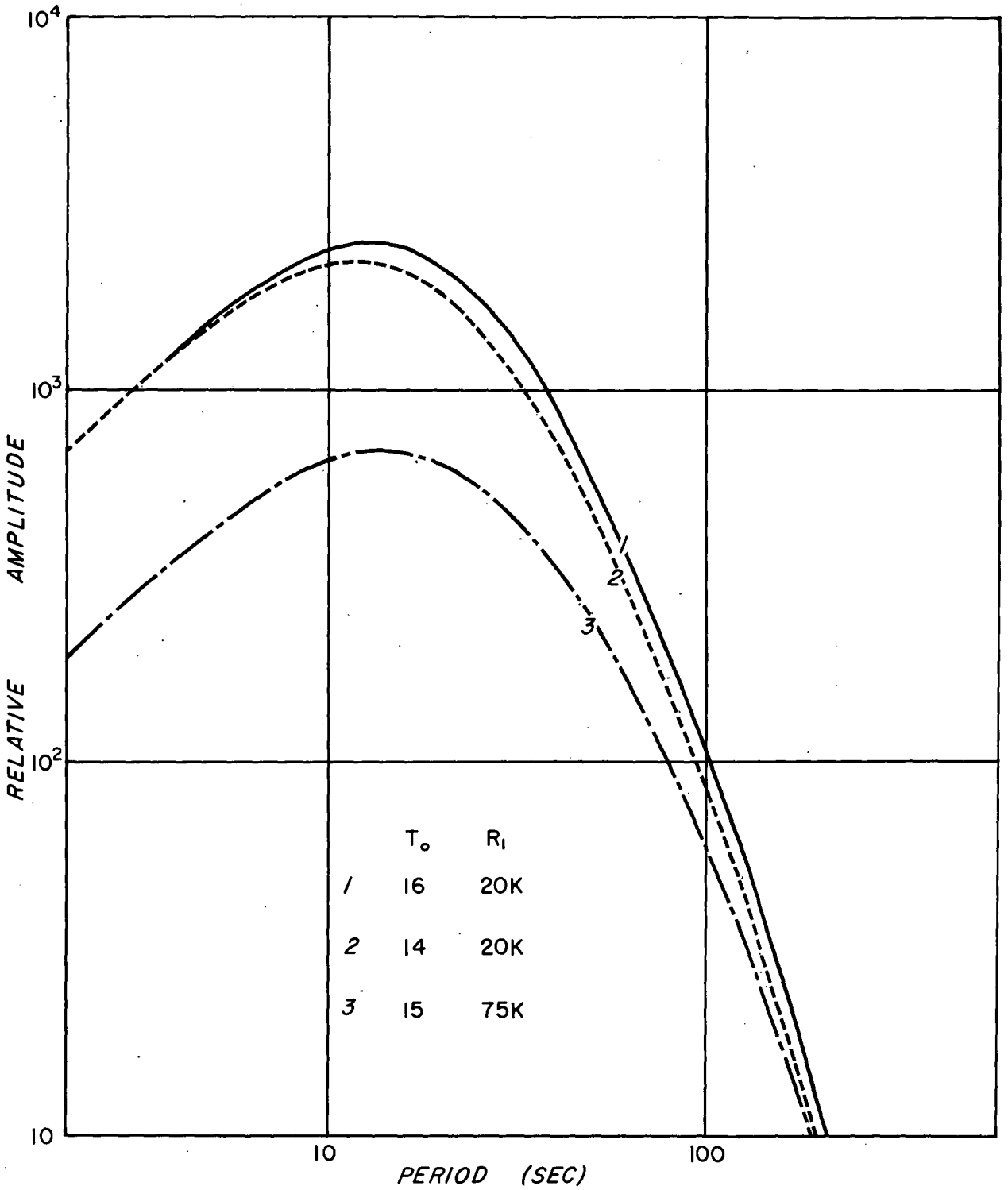

FIG. VI F EFFECT OF VARYING FREE PERIOD (T_o) AND RESISTOR R ON AMPLITUDE TRANSFORM

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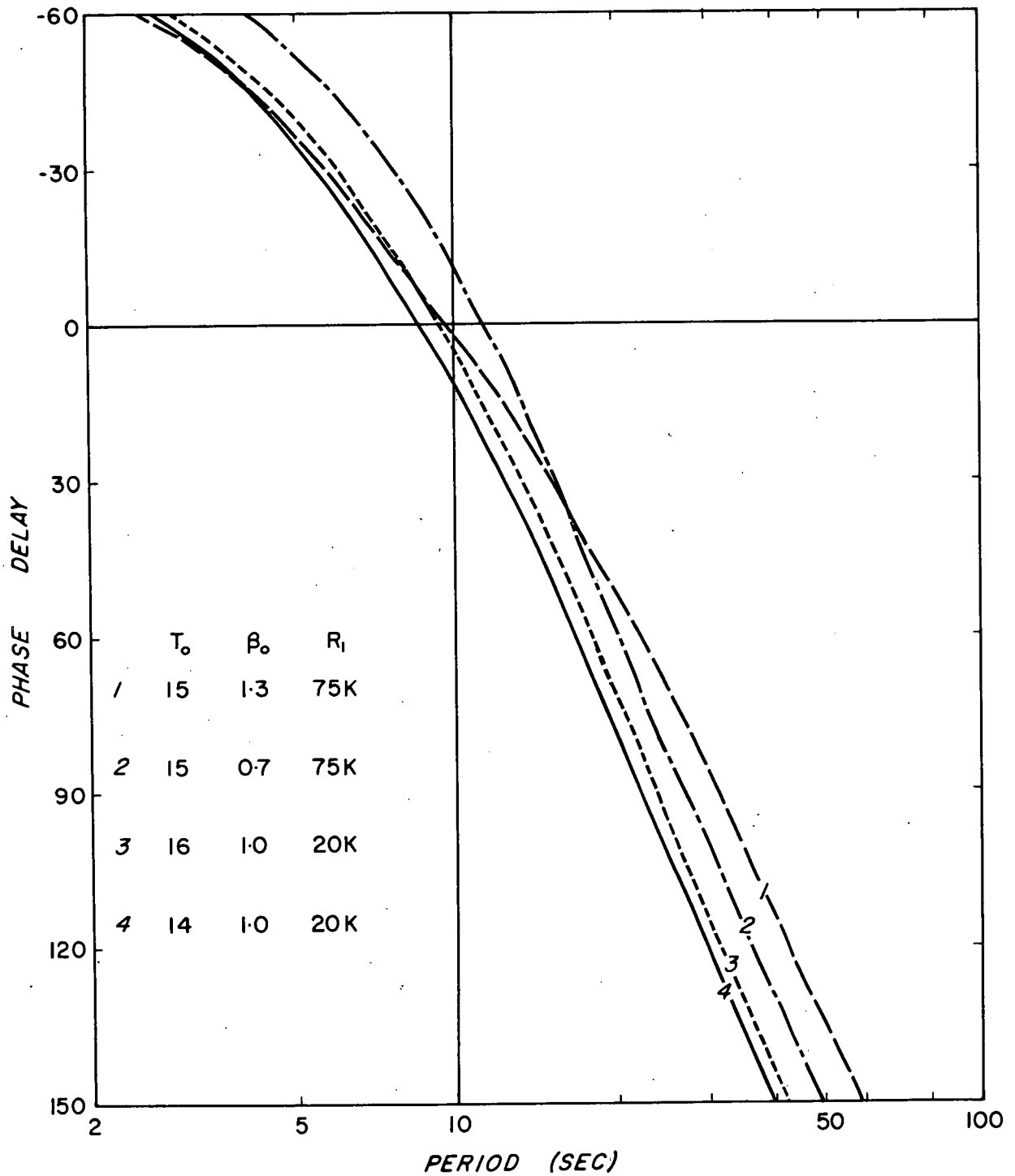

FIG. VIG

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$F(\omega)$ = velocity sensitivity = $x/\dot{u}$

$$= i\omega/(-\omega^2+2i\omega\beta_o\omega_o+\omega_o^2) = b/(p^2+ap+b)$$

is accordingly expressed as a polynomial in p, with constants a, b being determined by pendulum free period and damping.

Displacement or acceleration sensitivity are, respectively, $pF(\omega)$ and $F(\omega)/p$.

Given the form of u, $\dot{u}$, $\ddot{u}$, the pendulum displacement, x, can thus be determined.

Lowpass Filter Network Response:

The circuit, Fig. VI B, can be represented by an equivalent series of cascaded four terminal networks, with the transfer function of each represented by a constant (e.g. a pure resistance) or a polynomial in p (e.g. $1/pC$, a pure reactance).

System Response:

The total system response in frequency is then, simply, the multiple product of the individual network responses, including that of the seismometer. The complex roots of the resulting polynomial determine the position of zeros and poles of the system response in the complex frequency plane. Transfer function follows from evaluation of the polynomial, group delay from the differential of the phase angle with respect to frequency, and transient response from the inverse transform of the polynomial.

Response variations: Figs. VI F, G, H

(1) Filter response adjustment, R_1 (20k to 75k).

The corresponding amplitude and phase ranges are indicated. For low frequencies, the precision of method A is well within these ranges.

(2) Free period variations, 15 ± 1 sec. Figs. VI F, G show very small variations at the low frequency end of the spectrum.

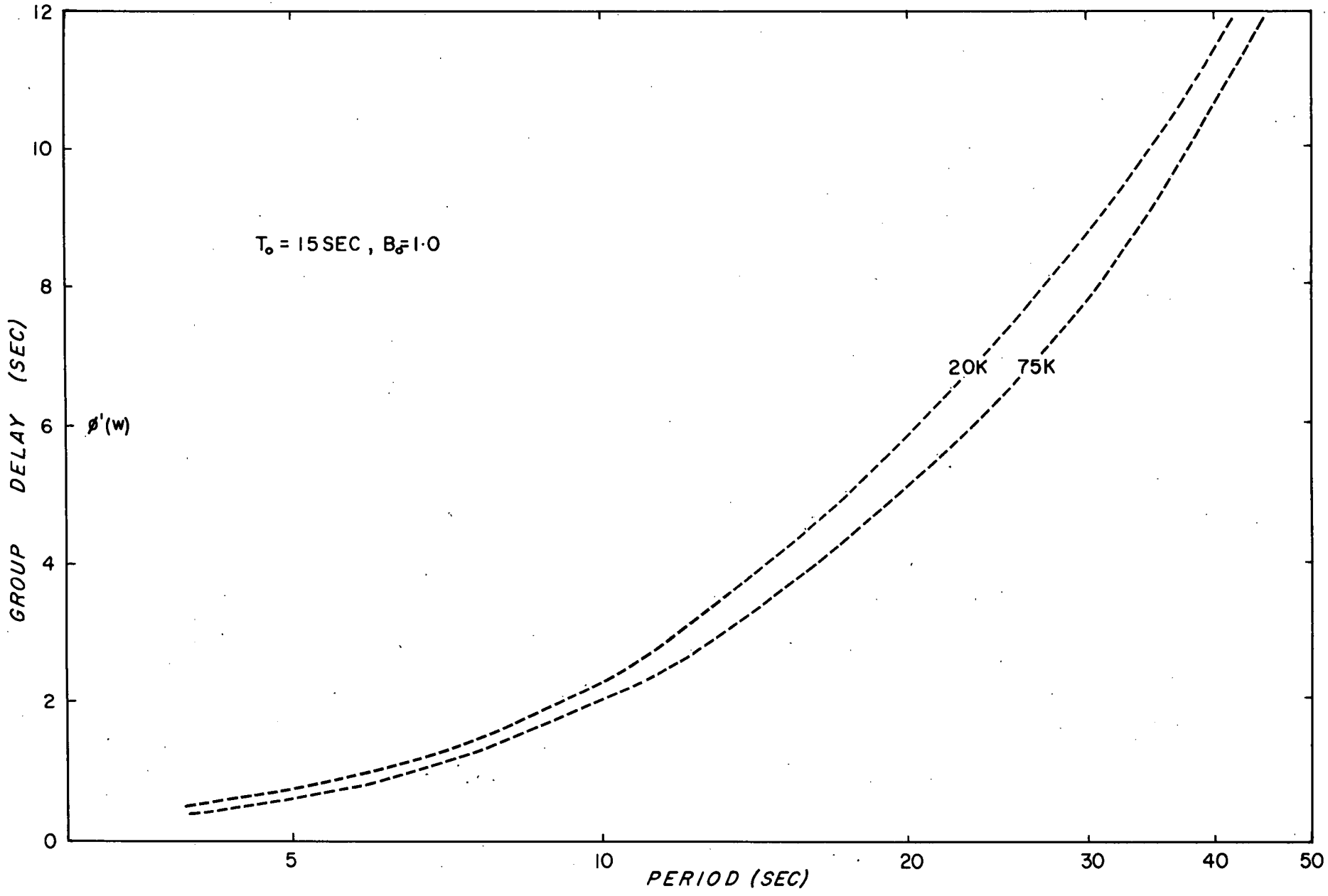

FIG. VI H GROUP DELAY AS A FUNCTION OF PERIOD FOR R = 20K, 75K

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(3) Damping co-efficient variations, 0.7 to 1.3 cause significant departures from the normal values at very low and very high frequencies. Those at low frequencies can be monitored using the transient calibration technique. At high frequencies, the shortest period used is 5 seconds, at which a maximum departure of $\pm 10^{o}$ in phase is possible, corresponding to 0.15 seconds in time i.e. less than 0.1% variation in phase velocity for a 1000 km path. This error is within acceptable limits.

(4) Group delay variations are shown as a function of period in Fig. VI H.

APPENDIX VII

SEISMOGRAM SPECTRAL ANALYSIS - SAMPLE OUTPUT LISTING

The following tables provide an example of the listing available from the program written to perform spectral analyses of digitised Rayleigh wave trains.

ER230 STEP FUNCTION CALIBRATION TEST 7C TAPINI 12 TH FEBRUARY 1966

LAGUERRE COEFFICIENTS, ZEROS

COEFF	VALUE	ZERO TIME			ORDINATE
C[0]	5.181_{10}-01	0	0	0.0	0.0000
C[1]	-1.702_{10}+00	0	0	0.0	0.0005
C[2]	2.430_{10}+00	0	0	0.2	0.0035
C[3]	-2.112_{10}+00	0	0	0.5	0.0115
C[4]	1.311_{10}+00	0	0	0.9	0.0292
C[5]	-5.911_{10}-01	0	0	1.5	0.0631
C[6]	8.273_{10}-02	0	0	2.2	0.1201
C[7]	2.368_{10}-01	0	0	3.0	0.1998
C[8]	-4.361_{10}-01	0	0	4.0	0.2822
C[9]	5.724_{10}-01	0	0	5.1	0.4127
C[10]	-6.034_{10}-01	0	0	6.4	0.5669
C[11]	6.203_{10}-01	0	0	7.7	0.7018
C[12]	-6.110_{10}-01	0	0	9.3	0.8278
C[13]	5.595_{10}-01	0	0	10.9	0.9214
C[14]	-5.251_{10}-01	0	0	12.7	0.9852
C[15]	4.844_{10}-01	0	0	14.7	0.9992
C[16]	-4.455_{10}-01	0	0	16.8	0.9675
C[17]	3.818_{10}-01	0	0	19.0	0.8904
C[18]	-3.403_{10}-01	0	0	21.4	0.7763
C[19]	2.865_{10}-01	0	0	23.9	0.6380
C[20]	-2.383_{10}-01	0	0	26.6	0.5127
C[21]	2.143_{10}-01	0	0	29.5	0.3781
C[22]	-1.654_{10}-01	0	0	32.5	0.2469
C[23]	1.534_{10}-01	0	0	35.7	0.1285
C[24]	-1.486_{10}-01	0	0	39.0	0.0350
C[25]	1.177_{10}-01	0	0	42.6	-0.0482
C[26]	-8.094_{10}-02	0	0	46.2	-0.1208
C[27]	8.239_{10}-02	0	0	50.1	-0.1665
C[28]	-6.888_{10}-02	0	0	54.2	-0.2056
C[29]	4.431_{10}-02	0	0	58.4	-0.2406
C[30]	-3.022_{10}-02	0	1	2.9	-0.2436
C[31]	1.254_{10}-02	0	1	7.5	-0.2466
C[32]	3.800_{10}-03	0	1	12.3	-0.2457
C[33]	-2.309_{10}-02	0	1	17.4	-0.2408
C[34]	1.462_{10}-02	0	1	22.7	-0.2242
C[35]	-1.163_{10}-02	0	1	28.2	-0.2082
C[36]	-1.140_{10}-02	0	1	34.0	-0.1981
C[37]	1.686_{10}-02	0	1	40.1	-0.1737
C[38]	-5.659_{10}-04	0	1	46.4	-0.1497
C[39]	-4.333_{10}-03	0	1	53.0	-0.1253
C[40]	8.908_{10}-03	0	1	59.9	-0.1056
C[41]	-5.113_{10}-03	0	2	7.1	-0.0900
C[42]	-1.035_{10}-02	0	2	14.7	-0.0734
C[43]	9.169_{10}-03	0	2	22.6	-0.0631
C[44]	1.155_{10}-02	0	2	31.0	-0.0436
C[45]	-3.744_{10}-03	0	2	39.8	-0.0428
C[46]	-4.568_{10}-03	0	2	49.1	-0.0317
C[47]	5.059_{10}-03	0	2	59.0	-0.0071
C[48]	4.859_{10}-03	0	3	9.5	0.0000
C[49]	-1.253_{10}-03	0	3	20.7	0.0000
C[50]	-2.004_{10}-03	0	3	32.7	0.0000
C[51]	-2.906_{10}-04	0	3	45.9	0.0000
C[52]	-1.984_{10}-03	0	4	0.3	0.0000
C[53]	-4.683_{10}-03	0	4	16.5	0.0000
C[54]	-3.973_{10}-03	0	4	35.3	0.0000

SEISMOGRAPH TRANSFER FUNCTION FROM FOURIER-LAGUERRE TRANSFORM

FREQ. CYC/SEC.	PERIOD SEC.	AMPLITUDE	PHASE RAD.	REAL	IMAG	DISPL	PHASE DEG.	PHASE SEC.
0.020	50.00	$1.147_{10}+01$	4.065	$-6.917_{10}+00$	$-9.147_{10}+00$	$2.276_{10}-02$	142.90	19.85
0.022	45.45	$1.006_{10}+01$	3.936	$-7.047_{10}+00$	$-7.176_{10}+00$	$2.656_{10}-02$	135.52	17.11
0.024	41.67	$8.845_{10}+00$	3.776	$-7.124_{10}+00$	$-5.242_{10}+00$	$3.033_{10}-02$	126.35	14.62
0.026	38.46	$7.461_{10}+00$	3.658	$-6.487_{10}+00$	$-3.686_{10}+00$	$3.253_{10}-02$	119.61	12.78
0.028	35.71	$6.739_{10}+00$	3.586	$-6.086_{10}+00$	$-2.894_{10}+00$	$3.670_{10}-02$	115.44	11.45
0.030	33.33	$6.176_{10}+00$	3.432	$-5.918_{10}+00$	$-1.766_{10}+00$	$4.136_{10}-02$	106.62	9.87
0.032	31.25	$5.179_{10}+00$	3.300	$-5.114_{10}+00$	$-8.178_{10}-01$	$4.209_{10}-02$	99.09	8.60
0.034	29.41	$4.551_{10}+00$	3.252	$-4.524_{10}+00$	$-5.011_{10}-01$	$4.437_{10}-02$	96.32	7.87
0.036	27.78	$4.191_{10}+00$	3.140	$-4.191_{10}+00$	$5.203_{10}-03$	$4.850_{10}-02$	89.93	6.94
0.038	26.32	$3.578_{10}+00$	3.024	$-3.553_{10}+00$	$4.198_{10}-01$	$4.870_{10}-02$	83.26	6.09
0.040	25.00	$3.137_{10}+00$	2.990	$-3.101_{10}+00$	$4.743_{10}-01$	$4.981_{10}-02$	81.31	5.65
0.042	23.81	$2.929_{10}+00$	2.895	$-2.840_{10}+00$	$7.163_{10}-01$	$5.383_{10}-02$	75.84	5.02
0.044	22.73	$2.481_{10}+00$	2.766	$-2.308_{10}+00$	$9.099_{10}-01$	$5.243_{10}-02$	68.49	4.32
0.046	21.74	$2.066_{10}+00$	2.770	$-1.925_{10}+00$	$7.495_{10}-01$	$4.988_{10}-02$	68.73	4.15
0.048	20.83	$1.981_{10}+00$	2.769	$-1.845_{10}+00$	$7.203_{10}-01$	$5.433_{10}-02$	68.67	3.97
0.050	20.00	$1.849_{10}+00$	2.663	$-1.641_{10}+00$	$8.520_{10}-01$	$5.734_{10}-02$	62.57	3.48
0.052	19.23	$1.621_{10}+00$	2.592	$-1.382_{10}+00$	$8.470_{10}-01$	$5.654_{10}-02$	58.50	3.12
0.054	18.52	$1.489_{10}+00$	2.544	$-1.231_{10}+00$	$8.384_{10}-01$	$5.817_{10}-02$	55.74	2.87
0.056	17.86	$1.350_{10}+00$	2.427	$-1.020_{10}+00$	$8.839_{10}-01$	$5.879_{10}-02$	49.08	2.43
0.058	17.24	$1.101_{10}+00$	2.333	$-7.599_{10}-01$	$7.964_{10}-01$	$5.327_{10}-02$	43.65	2.09
0.060	16.67	$8.929_{10}-01$	2.386	$-6.501_{10}-01$	$6.121_{10}-01$	$4.784_{10}-02$	46.72	2.16
0.062	16.13	$8.522_{10}-01$	2.475	$-6.696_{10}-01$	$5.272_{10}-01$	$5.038_{10}-02$	51.79	2.32
0.064	15.63	$8.542_{10}-01$	2.435	$-6.497_{10}-01$	$5.545_{10}-01$	$5.554_{10}-02$	49.52	2.15
0.066	15.15	$7.933_{10}-01$	2.339	$-5.510_{10}-01$	$5.708_{10}-01$	$5.657_{10}-02$	43.99	1.65
0.068	14.71	$6.946_{10}-01$	2.278	$-4.511_{10}-01$	$5.282_{10}-01$	$5.417_{10}-02$	40.50	1.65
0.070	14.29	$6.129_{10}-01$	2.267	$-3.932_{10}-01$	$4.701_{10}-01$	$5.215_{10}-02$	39.91	1.58

FOURIER TRANSFORM OF EVENT 16N RECORDED AT TAPINI ON 12TH FEBRUARY 1966

FUNDAMENTAL MODE, U=4.6 TO 2.2

EPICENTRE LAT: 3.8S LONG: 152.2E FOCAL DEPTH: 33KM.

ORIGIN TIME: 20 15 14.6 DELTA: 761KM. AZIMUTH TO STATION: 228.6

SEISMOGRAPH TRANSFER FUNCTION FROM ER230 STEP FUNCTION CALIBRATION TEST 7C TAPINI 12 TH FEBRUARY 1966

FREQ CYCLES/SEC.	PERIOD SEC.	AMPLITUDE	REAL	IMAG	PHASE DEG.	PHASE SEC.	CORRECTED ARRIVAL	APPARENT VELOCITY
0.020	50.00	$9.635_{10}+00$	$5.612_{10}+00$	$-7.832_{10}+00$	305.62	42.45	149.32	5.096
0.022	45.45	$1.000_{10}+01$	$2.403_{10}+00$	$-9.712_{10}+00$	283.90	35.85	152.62	4.986
0.024	41.67	$1.307_{10}+01$	$-3.292_{10}+00$	$-1.265_{10}+01$	255.42	29.56	155.94	4.880
0.026	38.46	$1.490_{10}+01$	$-1.145_{10}+01$	$-9.537_{10}+00$	219.79	23.48	159.77	4.763
0.028	35.71	$1.619_{10}+01$	$-1.604_{10}+01$	$-2.216_{10}+00$	187.86	18.64	162.95	4.670
0.030	33.33	$1.988_{10}+01$	$-1.731_{10}+01$	$9.770_{10}+00$	150.56	13.94	165.77	4.591
0.032	31.25	$2.424_{10}+01$	$-4.039_{10}+00$	$2.390_{10}+01$	99.59	8.65	169.53	4.489
0.034	29.41	$2.729_{10}+01$	$2.065_{10}+01$	$1.784_{10}+01$	40.83	3.34	173.88	4.377
0.036	27.78	$2.958_{10}+01$	$2.815_{10}+01$	$-9.090_{10}+00$	342.10	26.40	149.68	5.084
0.038	26.32	$3.239_{10}+01$	$9.813_{10}+00$	$-3.086_{10}+01$	287.64	21.03	154.02	4.941
0.040	25.00	$3.592_{10}+01$	$-2.024_{10}+01$	$-2.967_{10}+01$	235.71	16.37	158.07	4.814
0.042	23.81	$3.818_{10}+01$	$-3.813_{10}+01$	$-2.032_{10}+00$	183.05	12.11	161.56	4.710
0.044	22.73	$3.738_{10}+01$	$-2.361_{10}+01$	$2.897_{10}+01$	129.18	8.16	164.68	4.621
0.046	21.74	$3.504_{10}+01$	$9.506_{10}+00$	$3.372_{10}+01$	74.26	4.48	168.05	4.528
0.048	20.83	$3.462_{10}+01$	$3.337_{10}+01$	$9.227_{10}+00$	15.46	0.89	171.35	4.441
0.050	20.00	$3.737_{10}+01$	$2.372_{10}+01$	$-2.887_{10}+01$	309.40	17.19	154.46	4.927
0.052	19.23	$4.079_{10}+01$	$-2.178_{10}+01$	$-3.449_{10}+01$	237.73	12.70	158.50	4.801
0.054	18.52	$4.025_{10}+01$	$-3.851_{10}+01$	$1.172_{10}+01$	163.07	8.39	162.46	4.684
0.056	17.86	$3.323_{10}+01$	$2.968_{10}+00$	$3.310_{10}+01$	84.88	4.21	166.13	4.581
0.058	17.24	$2.278_{10}+01$	$2.278_{10}+01$	$3.237_{10}-01$	0.81	0.04	169.88	4.480
0.060	16.67	$1.371_{10}+01$	$1.568_{10}+00$	$-1.362_{10}+01$	276.57	12.80	157.11	4.844
0.062	16.13	$7.500_{10}+00$	$-4.370_{10}+00$	$-6.095_{10}+00$	234.36	10.50	159.51	4.771
0.064	15.62	$1.431_{10}+01$	$-1.119_{10}+01$	$-8.917_{10}+00$	218.56	9.49	160.29	4.748
0.066	15.15	$2.457_{10}+01$	$-2.238_{10}+01$	$1.014_{10}+01$	155.62	6.55	162.87	4.673
0.068	14.71	$2.775_{10}+01$	$4.045_{10}+00$	$2.745_{10}+01$	81.62	3.33	165.83	4.589
0.070	14.29	$2.316_{10}+01$	$2.315_{10}+01$	$-7.432_{10}-01$	358.16	14.21	154.83	4.915

APPARENT PHASE VELOCITIES FOR PATH 16N TO TAPINI

PERIOD	ARRIVAL TIME	PHASE INTEGER(N)	PHASE VELOCITIES C(N)	C(N+1)	C(N+2)	C(N-1)	C(N-2)
50.00	199.32	2	3.818	3.392	3.052	4.366	5.096
45.45	198.07	2	3.842	3.447	3.125	4.340	4.986
41.67	197.61	2	3.851	3.484	3.180	4.305	4.880
38.46	198.24	2	3.839	3.499	3.215	4.251	4.763
35.71	198.66	2	3.831	3.515	3.247	4.209	4.670
33.33	199.10	2	3.822	3.527	3.274	4.171	4.591
31.25	200.78	2	3.790	3.517	3.280	4.110	4.489
29.41	203.29	2	3.743	3.491	3.270	4.035	4.377
27.78	205.24	4	3.708	3.473	3.266	3.977	4.288
26.32	206.65	4	3.683	3.462	3.267	3.933	4.220
25.00	208.07	4	3.657	3.450	3.265	3.891	4.157
23.81	209.17	4	3.638	3.442	3.266	3.858	4.105
22.73	210.13	4	3.622	3.436	3.268	3.829	4.061
21.74	211.53	4	3.598	3.422	3.262	3.792	4.010
20.83	213.02	4	3.572	3.406	3.254	3.756	3.960
20.00	214.46	6	3.548	3.390	3.246	3.722	3.913
19.23	216.19	6	3.520	3.370	3.232	3.684	3.864
18.52	218.02	6	3.491	3.348	3.217	3.645	3.815
17.86	219.70	6	3.464	3.329	3.203	3.611	3.770
17.24	221.60	6	3.434	3.306	3.186	3.573	3.724
16.67	223.78	8	3.401	3.279	3.165	3.532	3.674

APPENDIX VIII

OBSERVED PHASE VELOCITIES

In this study, observed dispersion profiles have been adopted following examination of sets of superimposed data for several events having paths common to a particular region.

Tables of adopted phase velocities, corresponding to each event are provided for Chapter 3, and those corresponding to fitted polynomials, in Chapters 3, 4, 6, 8.

In this appendix complete sets of coefficients for polynomials of the form

$$C = \sum_{k=0}^{n} a_k T^k \quad , \quad n = 4 \text{ or } 5$$

are provided for reference. These data correspond to each profile plotted and discussed in Chapters 3, 4, 5, 6, 7.

Chapt./ Fig.	Profile	Polynomial Coefficient						S.D. KM/S
		a_o	$a_1 \cdot 10^2$	$a_2 \cdot 10^3$	$a_3 \cdot 10^4$	$a_4 \cdot 10^6$	$a_5 \cdot 10^9$	
3/15	I	2.6459676	1.7740255	2.5723917	-0.9741765	1.3023602	-6.1380516	.018
	II	2.6605538	1.1820261	2.9336375	-1.1178005	1.5332697	-7.4108461	.016
	III	2.6711910	0.6765646	3.2311624	-1.2392342	1.7320007	-8.5181774	.018
4/29	I	-2.1504870	70.0399217	-29.974235	5.8134585	-4.1690215	-	.031
	II	9.9996660	-194.35872	191.61973	-83.808113	170.88006	-1324.6332	.021
	III	7.8858968	-146.61905	150.9681	-66.852799	137.50283	-1070.9800	.022
	IV	5.5561901	-94.331421	105.09374	-48.457100	101.42800	-797.81507	.028
4/32	I	1.3811597	23.579123	-7.9960084	1.3560694	-0.8858412	-	.0373
	II	1.3679226	23.817350	-8.4864325	1.4748453	-0.9925398	-	.0371
	III	1.3648179	23.870335	-8.8573601	1.5670596	-1.0747312	-	.0375
	IV	1.3707170	23.759145	-9.1221959	1.6360310	-1.1362303	-	.0382
5/38	I	-4.5840609	104.78197	-50.267800	10.959235	-8.9599549	-	.051
	II	-4.3665981	101.52548	-48.828588	10.593762	-8.6078232	-	.044
	III	-4.1707369	98.621101	-47.603309	10.293979	-8.3239620	-	.042
	IV	-4.0100912	96.292858	-46.721726	10.090865	-8.1356792	-	.042
6/45	A	1.1973652	21.915123	-8.0076533	1.4549785	-1.0041046	-	.021

Chapt./ Fig.	Profile	Polynomial Coefficient						S.D. KM/S
		a_o	$a_1 \cdot 10^2$	$a_2 \cdot 10^3$	$a_3 \cdot 10^4$	$a_4 \cdot 10^6$	$a_5 \cdot 10^9$	
7/49	I	4.1990520	-30.907487	21.846412	-5.3032041	4.4315132	-	.017
	II	3.9865772	-27.516870	19.780789	-4.8373794	4.0505775	-	.014
	III	3.7895999	-24.374439	17.853798	-4.4013485	3.6945589	-	.013
	IV	3.6070240	-21.460786	16.053853	-3.9923284	3.3607048	-	.014
	V	3.4661236	-19.173256	14.590667	-3.6579007	3.0878034	-	.016
7/50	I	0.7976169	29.468817	-13.373848	3.3751545	-3.4345842	-	.064
	II	1.0012966	24.523277	-9.7369986	2.1031543	-1.9077129	-	.051
	III	1.1624739	20.572115	-6.9065415	1.1125084	-0.7122284	-	.051

APPENDIX IX

RAYLEIGH WAVE DISPERSION ACROSS AUSTRALIA - A SUMMARY

There have been several detailed studies of Rayleigh wave dispersion characteristics for various paths within Australia, mainly from recordings of the fundamental mode. Where interpretations have been attempted in terms of simple crustal models, thicknesses of between 30 and 40 km have been found in most studies. In the words of Thomas (1967a), "The Australian continental crust could reasonably be described as a block 39 km thick, with a shear velocity of 3.65 km/sec. overlying a mantle of shear velocity 4.75 km/sec. ..... The group velocity evidence suggests that the block extends northwards to New Guinea with no major changes."

Apart from the work of Thomas, important contributions have been made by Cooney (1962), Cleary (1963), Bolt and Niazi (1964), and more recently by Landisman, Dziewonski and Sato (1969), and are discussed below.

Higher mode Rayleigh waves have not been closely studied. Bolt (1957) first reported velocities of 3.03 km/sec. for the phase Rg for paths from a Western Australian earthquake of April 29, 1941, and the Adelaide earthquake of March 1, 1954 to Riverview. Oliver and Ewing (1958) published a group velocity dispersion curve for the M_{21} Rayleigh mode in the period range 8 to 15 seconds for a path from the Banda Sea to Perth. In addition, Cleary and Doyle (1962) made passing reference to possible recordings of the Rg phase in a study devoted to near earthquakes.

Theoretical computations of dispersion curves for several crustal models determined by refraction techniques have been published by Bolt and Butcher (1960) and Thomas (1966).

Observations of fundamental mode Rayleigh wave dispersion in Australia were first reported by de Jersey (1946) for a path from the

Finke River area in Central Australia to Brisbane. These observations of group velocity were restricted to periods of about 10 sec. and were of little real value for model interpretations.

Officer (1955) measured group velocity dispersion characteristics for paths beneath the Tasman Sea, and suggested that the crust beneath the Tasman Basin is about 10 km thick.

Cooney (1962) discussed group velocities for paths from the Robertson, N.S.W., earthquake of May 22, 1961 to Mundaring, Brisbane and Port Moresby. The limited range of periods available, rendered the model interpretation unreliable for the first two paths, but a useful estimate of 21-24 km was reported for crustal thickness beneath the mixed continental - oceanic path to Port Moresby.

Cleary (1963, 1967) used recordings from tripartite networks of stations in southern New South Wales to determine thicknesses of 35 to 37 km for the crust beneath the Snowy Mountains. This interpretation related observed phase velocities to the standard curves of Press (1956), and Cleary noted interference characteristics in some wavetrains.

New information on both phase and group velocities for paths in a north easterly azimuth from Mundaring, W.A. to the New Guinea and New Caledonia areas, and which contained the Chartres Towers station, was provided by Bolt and Niazi (1964). They determined a mean thickness of 30 to 35 km between these two stations. Brooks and Ripper (1966) found little difference between the group velocity dispersion for two paths from north western W.A. and Timor to Port Moresby. The path from Timor lay entirely beneath a water surface and thus this limited study suggested continuity of structure from Australia to New Guinea.

The most comprehensive investigation of fundamental mode characteristics is that by Thomas (1967a, 1967b, 1969). He measured phase and group velocities between pairs of World Wide Standard Seismograph

Stations, permitting a wide range of paths to be studied. Model interpretations by numerical inversion techniques compared the properties of single layer crustal models with multilayered models, and Thomas discussed the non uniqueness of solutions attempted using this method. In general, the crust appears to thicken beneath the eastern highlands, and as suggested by Bolt and Niazi (1964) the crust beneath the Coral Sea displays oceanic dispersion characteristics. Strong interference from laterally refracted wavetrains was reported especially for the path Chartres Towers - Hobart. Thomas deduced that the crust thinned near the Great Australian Bight, from the dispersion observed between Adelaide and Mundaring. The models matching dispersion observed between Adelaide and Chartres Towers contained the thickest crustal component (34 to 40 km), and the models for paths Riverview to Hobart and Adelaide to Hobart, the thinnest crustal layer (30 km).

Recent studies of Rayleigh wave dispersion in Australia using multiple filtering techniques were reported by Dziewonski and Landisman (1967). Group velocities beneath a structurally mixed path from the Andaman Sea to Adelaide were published by Dziewonski, Bloch and Landisman (1969).

Dispersion characteristics for periods exceeding 200 seconds, recently published for the path from Adelaide to Chartres Towers by Landisman, Dziewonski and Sato, 1969, represent a significant advance. These important detailed observations of both group and phase velocity afford the first opportunity for studying shear velocity characteristics beneath the Australian continent to depths of several hundred kilometers, in the upper mantle.

April, 1970.

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What makes an artist?:

Formative influences in the early lives of 34 Tasmanian visual artists.

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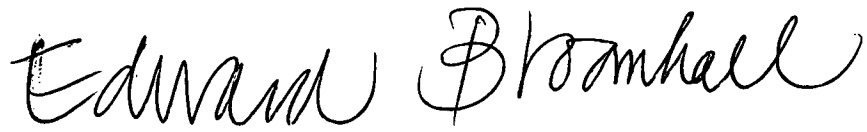
Submitted in fulfilment of the requirements
for the degree of Doctor of Philosophy

University of Tasmania

1996

This thesis contains no material which has been accepted for the award of any other higher degree or graduate diploma in any other university, and to the best of my knowledge and belief contains no material previously published or written by another person, except where due reference is made in the text.



Edward Broomhall

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I dedicate this work to the memory of my late parents, Mac and Grace Broomhall who encouraged me in my love of the visual arts.

Contents

List of tables

What makes an artist? Visual artists' accounts of significant influences in their early lives

Edward Broomhall

Abstract

The purpose of the study was to investigate the childhood experiences of contemporary, recognised visual artists in order to document and identify formative influences which nurtured their interest in visual art through childhood into mature professional development.

A total of thirty four artists were interviewed in the study. All subjects were residents of Tasmania. There were seventeen males and seventeen females. They were drawn from six media areas: painting, print making, ceramics, textiles, sculpture and book illustrating.

Naturalistic research was deemed to be an appropriate methodology for this study. The qualitative process of inductive analysis was used to generate information about significant influences on the development of young artists.

The instrument for the study was an interview schedule. Three areas were identified as being the basis of the interview schedule: art experiences at home, art experiences at school and art experiences at different phases through childhood.

Six major areas related to artistic development were identified: inherent ability, familial influences, access to imagery, technical knowledge, socialisation and school influences.

Findings of this study revealed that individuals who display a keen interest in art making from an early age, whether male or female, are aware of the urge to make images with available materials and begin to do so with a firm single-mindedness in early childhood. They seek to acquire technical skills and seek adult role models. Contact with art work and art resources seem to make an impact and was important.

The data revealed that the home environment was a significant source of support for subjects interviewed. Considering education policy and the promotion of gifted and talented programs for students, the case of artistically talented children may not align readily with current policy for other areas of talent and giftedness.

Results of the study indicate that the source of identification of artistic talent came not from the school but from parents and other family members. Further, home environmental influences were responsible for nurturing the inherent talent exhibited by the subjects interviewed for this study. In some cases teachers provided support and encouragement but generally the school was not the major source of influence. Identification as an artist does not seem to rely on an outside institution such as a school: rather, the identification is from the home environment and a 'significant other.'

In conclusion, the need of artistically talented children, to work in isolation, has significance for school art programs. It would seem more important for children, who are identified as artistically talented, to be placed in out-of-school programs rather than make allowance for those children in a regular school program.

Chapter 1

Background to the study

Introduction

This research developed from the writer's desire to identify strategies which support, encourage and challenge in the visual arts domain, those children whether in a school or non-school setting who, from an early age, demonstrate a keen interest in visual arts.

The original idea was generated by the researcher reflecting on his own childhood art-making experiences, both in the context of his home environment as well as at the schools he attended.

While still at primary school, the researcher developed an ambition to become a professional artist. An early influence was provided by the researcher's parents who provided art materials and gave him encouragement to produce

his art works. Two primary school teachers also provided encouragement and guidance. On one occasion, during primary school, a piece of the researcher's art work was selected for a State-wide exhibition. This event was significant in reinforcing his urge to become an artist. At secondary school, an art teacher helped the researcher expand his understanding of art by exposing him to examples of contemporary art and by lending him art journals and encouraging him to attend art exhibitions. In the opinion of the researcher, these experiences had a very positive effect on the quality of the researcher's production of art both in the school art studio and at home.

Purpose of the study

The purpose of the study was to investigate the childhood experiences of contemporary, recognised visual artists in order to document and identify formative influences which nurtured their interest in visual art through childhood into mature professional development.

Significance of the study

The significance of the study was to provide information which will enable parents and teachers to more fully understand the factors involved in developing and sustaining children's interest and expertise in the visual arts.

Definition of term

For the purpose of this study, a recognised visual artist is defined as an artist who is well known as a visual artist by other visual artists in Tasmania. A

recognised visual artist is one who practises and exhibits work in commercial and public galleries on a regular basis so that the work is familiar to other contemporary artists.

Background to the research

There are many ways in which a child may be identified at primary school as being 'talented' in drawing and/or painting. Often it was a perceptive primary school teacher who provided special attention to a child believed to be talented in this area. Sometimes, on the basis of an observation made by a primary school teacher, parents were encouraged to enrol their child in a special art class which usually operated out of school hours, for example, on a Saturday morning.

At an early age, children are sometimes attracted to specific domains of learning such as visual arts and music. Walters & Gardner (1986) have described this attraction as a 'crystallising experience'. In some instances such experiences lead to a later mastery of the domain but it is very rare for mastery to occur during childhood. The individual often persists working in the domain and develops refined skills in a relatively short period of time. Yehudi Menuhin is a musician who exhibited such a reaction, when at age four, he first heard a violin played at an orchestral concert (Gardner, 1993c:29). Following this experience, Menuhin asked his parents for a violin as a birthday present.

Gardner has identified a theme in his research about the development of creative individuals which concerns the relationship between a child and an adult creator. Gardner writes: 'This theme reflects my belief that important dimensions of adult creativity have their roots in the childhood of the creator' (1993a:30).

Renzulli (1986) has referred to a number of personality and environmental factors which have been identified in the research of others as being influential in the artistic development of children. The personality factors include: courage, intuition, energy, need for achievement, intuition, ego strength and a sense of destiny. The environmental factors, on the other hand, include: physical illness and/or well-being, stimulation of childhood interests, role model availability, family position, education of parents, parental personalities and chance factors such as living near an art museum.

Gardner (1993a) refers to a particular organising theme for his research about the development of creative individuals as 'the relationship between the creator and individuals'. These individuals include parents, teachers, mentors, colleagues and rivals (Gardner, 1993a:30). Mentoring is one of the oldest instructional models whereby an experienced adult acts as an expert counsellor to a younger protege. The use of a mentor provides a specialised form of education for children whose needs are not able to be met within the existing educational system. Strategies which are most often employed by the mentor system include the child observing and assisting the informed adult musician or painter.

Gardner, who has been undertaking research at Harvard University for well over a decade, has developed a theory of multiple intelligences (1982, 1983, 1989). Gardner has identified seven intelligences. They are: linguistic, logical mathematical, musical, bodily kinaesthetic, spatial, interpersonal and intrapersonal (Gardner, 1985). Gardner sees these seven intelligences as points

of departure for 'a more pluralistic view of intellect' (1990a:20). He emphasises the diverse ways in which the intelligences can be used either singularly or combined.

> I do not believe that any intelligence is inherently artistic or non artistic. Rather, intelligences singularly or in combination can be put to artistic uses. They can be used to create or to understand artistic works, to work with artistic symbol systems, to create artistic meanings(Gardner, 1990a:20).

Gardner has emphasised the individuality, in terms of possession of the intelligences, of each human being and pointed out that one successful artist might use a different combination of intelligences compared with another successful artist. An implication of Gardner's theory of multiple intelligences is that individuals are not creative in all areas. At best they are usually creative in just one domain. As an example, he pointed out that while Leonardo da Vinci was creative in the areas of spatial and logical abilities, it seems that there is no evidence that he was creative in language, music or understanding other people (Gardner, 1990a). According to Gardner, creativity, like intelligence has multiple aspects and he believes that creativity

> has a lot ... to do with getting to know the subject in great detail, and then being willing to take that knowledge and use it in new kinds of ways; the inclination to use knowledge in new ways is a personality feature and a value feature as much as a cognitive feature(Gardner, 1990a:21).

Gardner has claimed that art education has generally been viewed as a means of promoting self expression, creativity and imagination rather than as a craft to be mastered or as an area of study to be valued scholastically (Gardner, 1990b).

Polanyi (1958:206) asserts that 'all arts are learned by intelligently imitating the way they are practised by other persons in whom the learner places his confidence'.

Feldhusen (1986:117) conducted a study into the role of creative capacities in the development of certain individuals and his conclusions 'leave no doubt that creative capacity is an emerging construct in the lives of children who are destined to become creatively productive adults'. According to Feldhusen, personality functions including introversion, autonomy, individualism, sensitivity, alertness, flexibility and open-mindedness impact on the creative construct in childhood.

According to Ericson et al. (1993) 'talented' children are often treated as though they are special. Parents need to hold this belief if they are to devote the appropriate money, effort and time to the development of their child.

According to Howe (1993:89) one of the generalisations which can be stated concerning individuals who have made outstanding achievements in a particular area of learning is that they need to be self-directed and highly independent.

Freeman (1991) claimed that the development of the work of children in music and the fine arts had been significantly supported by the parents and the home environment. The basis of the interest and motivation in music or the fine arts in almost every instance was formed before the children began formal schooling. There was also evidence presented in this study that parents had often worked in partnership with their children to provide rich and varied opportunities for the children to respond to the environment.

When she was fourteen, Martha Graham attended a performance by an exotic dancer named Ruth St. Denis. She was stunned by the wonderful costumes as well as the gestures and expressive eyes of the dancer. As a result of this experience, Graham was inspired to learn to dance.

Howe has stated that 'a number of autobiographical accounts have drawn attention to the positive effects of the intensive reading that a child has done when confined to bed because of illness' (Howe, 1990:185). Being isolated makes it easier for an individual to concentrate on a special area of interest for extended periods of time. Howe has written that Isaac Newton was isolated and socially withdrawn as a child which may have impacted on his development of remarkable abilities while still very young (Howe, 1990:183).

William Gustin interviewed a mathematician about his childhood (Gustin, 1985:332). The subject's family lived some distance from town. He was the only boy in the family along with three sisters. The children played by themselves: 'they played games, practised music, played in the yard, and read books and magazines, which were all over the house' including *Scientific American, Natural History* and *National Geographic* (Gustin, 1984:336).

The writer H. G. Wells developed a long-lasting friendship at school with Sydney Bowkett who later became a playwright. They were companions with very similar interests (West, 1985).

Children tend to be intolerant of other children who seem to be unusual or who have different interests: 'the combined effect of being unlike one's peers in a number of ways, even small ones, may make it quite hard for a young prodigy to form comfortable social relationships with other children' (Howe, 1990:157).

A number of studies have been undertaken focussing on the need for teachers to pay attention to spontaneous drawings made by children outside the art class (Wilson, Hurwitz & Wilson, 1987; Duncum, 1985(b); Duncum, 1987).

A study by Wilson & Wilson (1977) involving adolescents revealed that almost all images drawn from memory could be traced to the popular media, 'how-to-draw' books and other sources from the adolescent subculture including comic books and television programs. They concluded that:

a. Children's graphic images generally have their origin in the images of others.

b. Children who use images from popular sources as well as their natural environment produce more imaginative and varied images than those who are discouraged from using images from popular sources.

Colangelo et al. (1993:164) found that the subjects in their study of the development of mechanical inventiveness reported that:

> they learned most of what they needed to know on their own, by reading books and magazines in their area of interest ... all, except one, claimed that school had not helped in any significant way with their inventiveness.

Theoretical framework

Research Question

What are the outcomes of interaction between a child's environment and a child's artistic propensity?

Assumption 1

Artistic abilities are inherent in certain individuals.

Sub-assumption 1.1

People with artistic abilities display a trait of perseverance.

Sub-assumption 1.2

Artistic abilities are enhanced through access to art techniques.

Assumption 2

Environmental influences nurture artistic propensity.

Sub-assumption 2.1

Childhood experiences nurture inherent artistic ability

Sub-assumption 2.2

The motivation to become an artist may be nurtured by

a. People within a child's familial environment (including parents, grandparents and other relatives).

b. A child's educational environment.

   i. Classroom teachers have the opportunity to nurture artistic motivation.

   ii. Specialist teachers have the opportunity to nurture artistic motivation.

c. Contact with art forms outside the school setting.

d. The degree of socialisation.

Assumption 3

The development of artistic propensity is an outcome of interaction between artistic ability and environmental influences.

Methodology

Key Interviews were selected as the research tool to be used for this study. Key Interviews serve to promote responses which are open-ended and rich in personal reminiscence. Interviews were semi-structured, utilising twenty two pre-planned questions.

The study was executed in the following manner:

a. The University of Tasmania Ethics Committee approved the conduct of the research.
b. The population was identified.
c. The subjects were identified and selected.
d. The data-gathering method was selected.
e. A list of questions was devised which related to the research assumptions.
f. A trial interview was conducted.
g. Modifications were made to the set of questions.
h. The data-gathering method was trialed.
i. The set of questions was mailed to each of the subjects who had agreed to participate in the research according to the rules of the University of Tasmania Ethics Committee.

j. The interviews were conducted and recorded on audio tapes.
k. The taped interviews were transcribed.
l. The information was indexed and coded using NUD.IST.
m. Categories were identified and recorded.

Data analysis

NUD.IST was selected as the data analysis tool for the requirements of this research. NUD.IST is the acronym for 'Non-numerical Unstructured Data Indexing, Searching and Theorising'.
NUD.IST enables qualitative researchers who have gathered data in text form to label units of text with codes. The researcher used NUD.IST to index and explore the indexed items according to themes. Categories were developed, identified, classified and verified.

Bias of research

Though the writer had preconceived ideas about the study, a conscious effort was made to ensure that the categories developed from the data were the result of unbiased analysis.

Ethical considerations

The University of Tasmania Ethics Committee approved the conduct of the research.

Summary

This chapter described the purpose and significance of the study, the theoretical framework including the basic assumptions underlying the research questions as the methodology and data analysis used by the researcher. A review of the literature will be presented in Chapter two. Chapter three will focus on the methodology used to conduct the study. In Chapter four the results are analysed and discussed. The final chapter provides the reader with a summary of the study, a discussion of the results and recommendations for further research.

Chapter 2

Review of literature

Introduction

The purpose of the study was to investigate the childhood experiences of contemporary, recognised visual artists in order to document and identify formative influences which nurtured their interest in visual art through childhood into mature professional development.

The chapter is structured according to the following headings: inherent artistic ability, familial factors, school influences, socialisation, technical knowledge and access to the arts. These headings were selected by the researcher to organise the information because they were the significant themes to emerge from the literature.

Biographical data derived from recognised artists may provide insights into aspects of childhood which are linked to artistic practice as adults. Childhood experiences may appear to nurture the development and realisation of artistic talent in the course of the career of an artist. This chapter presents a review of research literature concerning the interaction between nature and nurture and the factors involved in that interaction. The biographies and autobiographies of historical artists were used to obtain the relevant data.

Dutton (1992) recorded a selection of interviews with Australian artists which were conducted by de Berg in 1957. These interviews presented information about problems and processes of working in paint, clay and various other media, as well as recording the progress and development toward a professional career as an artist. Artists made reference to their childhood experiences along with information about their developmental years which is relevant to this research study.

Artists of particular note whose lives are referred to throughout this chapter are: Noel Counihan, John Olsen, Andy Warhol, Pablo Picasso, Salvador Dali, Stanley Spencer, Juan Gris, Auguste Renoir and Eugene Delacroix.

Research studies by Dutton (1992), Cane (1951), Rodman (1957), Hetherington (1963), Walberg (1969), Orczyk & Walberg (1983), referred to in this chapter, have relied on interviews and case study techniques.

Inherent artistic ability

Young people who later become artists may be identified as talented in art at an early age and the talent appears to be inherent. Cane, an American art educator/psychologist, was appointed as a consultant to the Counselling Centre for Gifted Children at New York University in 1936. Professor Harvey Zorbaugh set up the clinic which was based in the School of Education at New York University and a range of specialists was engaged to work with children who were identified as being artistic. Cane became the art consultant and her tasks were to classify these children by analysing the art work submitted to the clinic and subsequently to advise the parents of the children so recognised. She undertook a study of several children and their artistic development from early

childhood through to adolescence. Cane was one of the first art researchers to use a case study approach in an attempt to establish why children, who appear to be gifted artistically, are the way they are.

A key point that Cane (1951:180) made was that the development of the art work of a particular child may depend on the understanding and support of the people around the child for his/her art products. She went on to state that the imaginative artistic child 'sees things differently from concrete, conventionally-minded people, whether parents or classmates or regular teachers.'

Walberg, Rasher & Parkinson (1979:28) have been involved in research since the late 1960s (Walberg, 1969, 1971), about the traits of eminent artists of the past as well as young Americans who have won competitive awards and prizes in areas such as music, graphic and performing arts, writing and science. Some of the most common traits identified were that:

a. the individuals were questioning and curious, and
b. they had a strong desire to excel (Walberg, Rasher & Parkinson 1979:228).

In a study undertaken with Orczyk, Walberg (1983) arrived at the following conclusions:

a. adolescent creativity correlates highly with various psychological, familial and cultural conditions;

b. the subjects had an ability to persevere, and

c. there was a strong intellectual motivation.

According to Dimmack (1974), the Australian artist Noel Counihan believed that his talent for drawing was a vital and sustaining factor in his childhood.

He was not very strong physically and his artistic skills compensated for this when he was older.

In a study by Dutton (1992), John Olsen reported that he was constantly drawing as a child and no blank piece of paper was safe from him including his mother's cookery book.

Another Australian artist, Lloyd Rees began painting when he was about six years old. He painted watercolours inside the lids of his mother's cylindrical hat boxes. He made friezes of railway trains along the verandah walls of his childhood home which were not altogether acceptable to his parents (Dutton, 1992:73).

Andy Warhol, growing up in New York, rarely played ball games with the local children; instead, he preferred to spend his time drawing with crayons. He enjoyed going to the city shops with his mother and helped her select hats and other clothing. On one occasion he painted gold edges around a black felt hat she had purchased. Because of these activities he was considered to be an artist by many of his peers. When he finally began school, his first teacher remembered that he was 'quiet, not at all outgoing and ... real good in drawing' (Bockris, 1990:18).

Nathan Oliveira in an interview with Dobbs (1981:20) stated that:

> as a young child I became aware of the fact that I was very articulate visually. I found drawing a natural means of communication .... I felt quite insecure except when it came to art. Then I felt extremely capable, and I could out-perform anybody around .... I always knew I could describe far better what I wanted to describe if I could do it visually.

According to Pablo Picasso's mother, he could draw before he could speak, and the first sound that he made was *'piz, piz ...'*- baby language for *lapiz* which is pencil. He drew spirals that represented a *torruela,* which is a fritter shaped like

a snail which was a common food eaten in his household. Picasso had no young male relatives to play with and sometimes, while other children played under the trees, he made drawings in the dirt.

According to his sister, Juan Gris' interest in art making became evident when he was six or seven years old: 'from the day when he was first sent to school.' She wrote that:

> he would fill the margins of his exercise books with sketches of his masters, of his school fellows and of everything he saw, so that he made scarcely any progress with his studies and had to accept many a rebuke both from his teachers and from his parents (Kahnweiler, 1947: 6).

There was pressure on him by his parents to pursue a business career, however he eventually overcame their opposition to his studying art (Kahnweiler, 1947).

Several artists have recalled decorating their exercise books at school and other items at home. For example, according to Deslandres (1963), Eugene Delacroix filled the margins of his school books with sketches. The French Impressionist, Auguste Renoir also drew pictures in the margins of his school exercise books (Renoir, 1962:53). At school, Bell showed no special aptitude for an artist's career except illegally decorating his exercise books with pen and pencil drawings of grotesque heads (Hetherington, 1963:7). When he was ten or eleven years old, Picasso covered the margins and flyleaves of his school text books with drawings and doodles: pigeons, doves, cats , an actor, the Eiffel Tower, inkblots transformed into figures and a drawing of a donkey mounting an ass to illustrate a schoolboy's bawdy quatrain. These thumbnail sketches are remarkably observant and spirited (Richardson, 1991:42).

Inherent ability has also been identified in studies which have considered developmental influences of individuals practicising in other disciplines including music, mathematics and architecture.

Howe & Sloboda found in their study of the early lives of musicians that 'it was clear from the interview responses that a child's musical experiences were strongly permeated by particular beliefs about the causes of unusual musical ability' (1991(a):46). There is a view that there is a close correlation between the ability of a child in a particular area such as music and the idea that these abilities can be inherited. Whether this is a true or false assumption does not really matter. The actual belief that it is possible to inherit talents can be a very powerful motivational force.

In the study of the childhood of some American architects by MacKinnon(1978) it was found that all of the subjects manifested considerable interest and skill in drawing and painting from an early age.

Gustin's subject in his study of a mathematician (Gustin, 1985:332) indicated that his parents were aware of 'certain mathematical tendencies' in him by the time that he was five years old. He was interested in how things worked. He was one of those children fascinated by mechanical toys and machines and he enjoyed taking them apart.

Perseverance

Some artists appear to exhibit an individual dedication to make art despite obstacles and even overt opposition. Michelangelo, for example, was harshly reprimanded and beaten by his father and other older members of his family when he became so obsessed with drawing that he spent as much time as possible involved in the activity. However, later, when he realised that there was no hope of stopping his son from drawing, he had Michelangelo apprenticed to Ghirlandaio (Vasari, 1965). George Baldessin was always very interested in drawing but he was never encouraged because of his background. It was expected that he would become a bricklayer or a plumber. David

Strachan's father wanted him to study medicine as his siblings had done, however he was rebellious and refused. Eventually he was sent to the Slade School of Art where he studied for three years (Dutton, 1992).

Again, the research conducted about the early lives of outstanding practitioners in other disciplines has identified a dedication and perseverance towards the practice of that discipline.

Howe & Sloboda (1991(b):51) found that an important issue underlying the development of musical ability in young musicians was the perseverance of not only the children but also the parents in the process of getting the work, such as regular practice, completed.

The subjects in the study by MacKinnon of American architects were reported to have worked independently. They were self assertive and often rebellious. They worked hard and were highly motivated from an early age (MacKinnon, 1978:304).

Feldman (1980:170) concluded that 'as a child reaches the elementary years ... the child will begin to seek greater skill and depth in instruction within a field.'

Familial factors

> ' How each of us experiences events in the world we inhabit determines how we are influenced by those events, and what we learn from them' (Howe, 1990:58).

The influence and support of parents, grandparents and other family members may have an influence on the way a child with artistic ability pursues that ability. Many artists have indicated that a parent was a positive and encouraging influence on their interest and involvement in art-making during

their childhood. For some artists, as children, it was through the influence of a parent that they first came into contact with professional adult artists.

Cane's study (1951) focussed on two artistically gifted students . She documented and explained the importance of parental support and encouragement. She claimed that parents:

> By using their intelligence and intuition in co-operating with the teacher and by keeping suitable materials easily available, [they] can contribute their share towards their children's growth (Cane, 1951:180).

According to Walberg (1971), some of the more common social and family conditions in which the subjects of his study lived were:

a. they were exposed to many adults at an early age;

b. they were permitted to explore their home environment ;

c. materials and cultural stimuli related to their field of interest were available;

d. they had contact with significant adults working in their field of interest, and

e. they were encouraged by a parent and/or a teacher.

While all of these conditions were not common to each subject, they were significant for many (Walberg, 1979:229).

Lasarte (in Cirlot, 1972) has stated that it is possible to identify three major influences on the early work of Picasso - that is, during his childhood and adolescence.
They are :

a. his home environment,

b. his early school training followed by the exemplars provided by the work of other artists, and

c. what Lasarte refers to as non-academic art.

The French painter, Edgar Degas' father was a cultivated man and a connoisseur of music and painting. He took his son to visit some of the art collectors where Degas saw engravings by Prud'hon, and many drawings by important artists including Ingres' *Odalisque au Turban* . His father organised a space for him to use as a studio when he was in his early teens, and there he produced his first etchings using the method he had been taught by the artist and collector, Gregorion Soutzo (Bouret, 1965).

Stanley Spencer, who grew up in the English village of Cookham, and his brothers and sisters were read stories by their parents every evening. Many of the stories were illustrated; the drawings by Brinsley Le Fanu for *Brer Rabbit* were an early influence on the work of Spencer. Later, he greatly admired the illustrations of Arthur Rackham. As a child , he was provided with crayons, drawing books, and occasionally some transfers. Spencer drew prolifically, incorporating images from the surrounding environment of Cookham village in his fantasy works (Spencer, 1991).

As a child, Auguste Renoir was given some exercise books and a supply of pencils by a friend of the family. He drew portraits of his parents, his sister, brothers, and neighbours as well as cats and dogs in the neighbourhood. None of the people who posed for him while he was young really suspected that Renoir's love for drawing would lead to it becoming his profession. Renoir himself hoped that he might be a fashion designer or a decorator of porcelain and china (Renoir, 1962). Renoir, whose father was a tailor, would often draw on the floor with his father's tailors chalk and, although his father was annoyed when his chalk disappeared, he thought that the figures his son drew on the floor were 'not bad at all' (Renoir, 1962:53).

The atmosphere of the house, where the contemporary Australian artist Arthur Boyd grew up at Murrumbeena, was always of people painting, drawing and modelling (Hetherington, 1963). Boyd stated that his relationship with his grandfather was a very happy one. He spent three years with him at Rosebud, where he was given complete freedom to paint and lots of encouragement (Philipp, 1967).

Kathleen O'Connor said that when she was a small child her father always 'encouraged her to be an artist' (Dutton, 1992). Vida Lahey had a similar experience. Although her father was not involved in art making, he had a love of nature such as wild flowers. He had a sensitive nature and encouraged Lahey to appreciate the beauty of her environment. Dutton stated that Lahey:

> was interested in any type of art, really. I often think of my father- I really owed a great deal of that to my father because, although he wasn't a practitioner of any sort, ... he had a very sensitive nature — he loved nature and wild flowers (Dutton, 1992:34).

Alison Rehfisch, in her interview with de Berg, indicated that she was fortunate that her parents were very interested in painting and in all the arts, including music and literature. Her mother was particularly encouraging

because she made art and she was a good musician. Rehfisch was a very good painter and she did wood carving (Dutton, 1992).

Margo Lewers's father was a painter and she believed that she inherited something from him. As a small child she used to paint wild flowers and expressed a desire to go to an art school. Her father died when she was five and, although her mother couldn't afford to send her to art school, Lewers continued to paint (Dutton, 1992:102).

Michael Kmit was attracted to painting when he was growing up in central Europe. He remembered when he was about four years old, being with his mother and drawing images with his fingers in the ice on the frozen windows of his home:

> I used it for all my first pictures - and with a frozen finger perhaps! And at the time my father came, it was ten o'clock in the morning, and I liked to draw his attention to my unexpected abilities, so it was he who saw this picture I draw with my frozen fingers on the window, he said, ' He become a painter!' and he just went and bought me watercolours and crayons, and it was how my career as a painter started(Dutton, 1992:112).

When the American painter, Thomas Hart Benton was six or seven years old, the interior of his parents' house was freshly papered. There was a stair way which went around a landing from the lower hall of the house up to the second floor. Benton's first mural was a long freight train in charcoal which he drew on the new paper up the stairway (Benton, 1937).

Oscar Kokoschka's first memories of his childhood were purely visual. In his biography (Kokoschka, 1974) he recalled sleeping in an old wooden cot strung with a net of green string; being cuddled by an aunt who wore large hats decorated with feathers; his mother carrying him to the window of his bedroom from which he could see a balcony decorated with stucco caryatids

with large breasts; the pattern made of brightly coloured flowers which decorated the wallpaper in his bedroom; dragons' heads which were carved on the posts of the verandah of the family home; a golden bracelet in the shape of a snake with red eyes which was worn by his first teacher.

An older female friend of the family often read Kokoschka fairytales and stories about famous heroes and heroines. His father also gave him books including an illustrated edition of the Greek myths and a copy of *Orbis pictus* of the seventeenth-century Bishop of the Moravian Brethren, Jan Amos Comenius. *Orbis pictus* set out everything in pictures, suitable for children, he knew to exist. He was given a tin of watercolour paints and brushes. After he had completed his homework, his favourite activity was painting.

Kokoschka's father was a skilled goldsmith and he often gave his son interesting toys. One, of particular interest, was a magic lantern with brightly coloured pictures which moved due to the heat given out by a small lamp.

Andy Warhol was born in 1928 in the immigrant ghetto of Soho in Pittsburg. This was the year before the great stock market crash which led to the great depression of 1929. Warhol's father lost his meagre savings and to help out with the family finances, his mother cut flowers from old fruit tin cans, covered them with crepe paper, filled the cans with paper flowers which she designed and constructed, and sold them from door to door. According to Bockris (1990:12) Warhol identified this activity by his mother as the reason why he made his first paintings of tin cans. His mother always had many cans around the house including soup cans. Warhol likened his mother to the primitives and believed that she was 'a real good and correct artist' (Warhol in Bockris, 1990:12).

Although Warhol was introduced to a formal school environment when he was just four years old, he was emotionally upset by the experience, so his

mother kept him at home with her until he was six. During these two years he spent most of his time with his mother, who enjoyed drawing. As she drew, Andy made many drawings too. Often the drawings were of domestic subjects such as the family cat.

During his childhood, Warhol suffered three breakdowns which have been referred to as Sydenham's chorea. The tremors of the face, arms and legs ensured that he remained inside, often in bed.

As his hands began to stop shaking after his long illness Warhol coloured the colouring books, cut and pasted illustrations from the popular magazines to construct collages and played with the paper dolls. During this time one of his brothers taught him the technique of transferring an image from the page of a magazine onto a sheet of paper by putting wax onto the surface of an image and then rubbing the back of the image with a spoon. A sister rewarded him with a Hershey bar as he completed each new page of a colouring book. The same sister acted as a studio assistant by providing the necessary materials and admiring Warhol's drawings and collages. He returned to school against his will, before he was physically strong, and suffered a relapse. The outcome was that he was required to spend another month in bed where he continued to enjoy the art-making activities. He lived in a world of fantasy. He constantly fantasised about being a movie star in Hollywood (Bockris,1990:21). Shirley Temple was the focus of his fantasies. He tried to emulate her, even imitating her film gestures.

Warhol was usually the youngest person in his class. He was expected to be precocious, but he was not. He found school boring except for art and history. His mother had a genuine talent for drawing and all of her sons imitated her rather primitive style.

Warhol was considered to be a natural at drawing right from the beginning and he quickly became a prolific drawer. His mother was pleased and she encouraged him whenever possible. His drawing ability helped her define his oddness to others. While still at primary school, Warhol was sketching portraits of neighbours and selling them to raise pocket money. He spent his pocket money on movie magazines and for admission to the Saturday movie matinees.

Pablo Picasso often made drawings for his young cousins. One of the earliest drawings to survive is of Hercules wielding a club. He used a plaster statue, which decorated the family home, as a model for this drawing. When he was seven, Picasso made paper cut outs, using an aunt's embroidery scissors. His 'skilful hands cut out animals, flowers, strange garlands and groups of figures' (Richardson, 1991:31). He did not enjoy school and often requested to be allowed to remain home and make drawings. His parents gave him drawing paper and pencils. According to Picasso, he preferred to draw his father's pigeons rather than attend class (Richardson, 1991:31).

Don Jose Ruiz Blasco, who was Picasso's father, was at one time a museum curator. While living in Malaga in Spain, he also restored damaged paintings which were part of the museum collection. According to Cirlot, he painted in an academic style with accurate, realistic details of the subjects (Cirlot, 1972). He specialised in painting pigeons and still life pieces. He and his wife recognised their son's artistic skill and supported him by providing materials and encouragement. Picasso's father was his first teacher and since he specialised in pigeons, he encouraged his son to draw them until he could reproduce the images correctly. He even had the claws of a dead pigeon fastened to the wall for Picasso to draw. Drawing was Picasso's first mode of expression and when he was about ten years old, his father introduced him to painting. Don Jose was then appointed drawing teacher at the de Guarda Institute in Corunna (Cirlot, 1972).

While he was a child, Picasso had an interest in recording family portraits. He made many drawings of his sister, Lola, as she played with her friends, helped her mother in the kitchen and even when she was either getting in or out of bed. He sketched hands in every position imaginable and he produced lots of studies of heads. As well, he produced imaginative sketches of historical battle scenes (Cirlot, 1972).

The drawings he made out of school were influenced by his father's style. Although some writers have referred to Picasso's legendary innate giftedness (Sabartes, 1949; Cirlot, 1972; Penrose, 1981), Richardson (1991:48) is of the opinion that Picasso worked 'very very hard'; Richardson goes on to indicate that 'Hard work ... came naturally, thanks to the energy and concentration that he inherited from his mother' Later in life, Picasso himself said 'I believe in nothing but work. You cannot have an art without hard work: manual as well as cerebral dexterity' (Richardson, 1991:48).

At home, Picasso continued to refine his drawing and painting skills by producing portraits of his sister, his father and himself. His mother was apparently far too busy to spare the time to pose for her son. His sister was the only female model available to him on a regular basis. He painted a series of deathbed and sick-room scenes. It is believed that these were prompted by his reflection on the sad death of another sister from diphtheria. He used his sister and father as models for these paintings. He executed many self portraits. Like most adolescents, he 'took narcissistic delight in scrutinising his looks in a mirror' (Richardson, 1991:83) Picasso painted and drew himself in many different roles in his self portraits. He used fantasy to portray himself in a variety of dramatic identities.

According to a biographer of Salvador Dali, (Alexandrian, 1974), he was born in 1904 at Figueras, in Spain. He was involved in art from an early age and he received encouragement from all members of his family (Alexandrian, 1974). He was born three years after an earlier brother had died and he was an only child for four years until the birth of a sister. He displayed considerable artistic talent before he was six years old. Although his parents were not wealthy, they were generous with the support which they gave to their son (Descharnes, 1972). His parents provided him with an old laundry, which was situated at the top of the family home, as a place to make art. He used the pliable wooden lids of old hat boxes, which he stole from an aunt's millinery shop, as supports for his paintings.

Studies conducted by Howe & Sloboda (1991), MacKinnon (1978), Bloom (1985), Gustin (1985) and Gardner (1988) about the childhood of musicians, mathematicians, architects and swimmers have identified the significant impact of parents on their development in a particular discipline.

Howe & Sloboda in their study of the early lives of musicians found that:

> The majority of parents had at some time experienced some active participation in music, and it is clear from the interviews that the early home environments of a substantial number of the subjects were strongly influenced by their parents' musical interests (Howe and Sloboda, 1991:43).

MacKinnon (1962:11), in a study of the early development of some American architects indicated that in many cases in the study one or both parents were of artistic temperament and considerable skill. Often it was the mother who fostered the potentialities of the child by setting an example and by providing some tuition.

A group of researchers at the University of Chicago, led by Benjamin Bloom (1985) examined the early lives of children who had developed remarkable accomplishments by early adulthood. Information about family life and early childhood experiences were collected by the researchers interviewing the subjects. The researchers also interviewed the parents and teachers who had been associated with the subjects. The studies investigated the early family lives of sculptors, concert pianists, mathematicians, tennis champions and Olympic swimmers.

The Chicago studies report that in most instances, the children began developing special skills in their area of interest in the context of activities engaged in at home. The parents had encouraged and supported their children's interests by providing appropriate resources in the home and by taking them to special classes for expert tuition.

One of the researchers, William Gustin, has written about a mathematician whose grandfather was a significant influence on his mathematical development. The subject spent a month every summer with his grandfather who was an academic with a PhD in mathematics. According to the subject:

> I think my grandfather did influence me a great deal in the direction of mathematics. There's no doubt that he's the greatest hero I've ever had, and it was clear to me that he regarded pure mathematics as the highest calling (Gustin, 1984:339).

Gardner, in his book about creative historical figures, stated that Einstein was provided with books about physics by a friend of the family who had noted his interest in that aspect of learning (Gardner, 1993a:90).

The family environment

According to Freeman (1991:6), how well children develop their abilities depends greatly on the environment they live in. Freeman goes on to state that intellectual growth develops best in a setting of steady, balanced relationships. Important home influences are material provision for the children such as space, books, paper, art materials (for those interested in art making) or musical instruments (for those who are motivated to play music).

Leonardo da Vinci grew up in the countryside of Tuscany which is a wine growing area of Italy. According to historical records about Italian Renaissance artists, he made intimate observations of nature. When Leonardo was about thirteen, according to the historian, Vasari, he painted a dragon on the wooden shield of a peasant who was employed by his father. He collected some large and small lizards, crickets, butterflies, bats, grasshoppers, serpents and other small animals, from which he composed a great and ugly creature (Vasari, 1965).

Even wet weather did not deter Pablo Picasso from spending hours making drawings of the coastal landscape near where he lived. Many of his early paintings were executed on the lids of old cigar boxes. He painted portraits of relatives and friends of his family. Picasso loved to go to the bullfights. He worked in the open air to get some relief from the life class which was very crowded. He set up his easel in a popular park where he sketched ponds, palm trees, kiosk, and miniature man-made mountains and he used cigar box lids to paint impressions of the sea, the sky and interesting scenes around Barcelona.

He made some studies of a quarry which, according to Richardson 'are the boy's first conscious attempt to paint a modern picture' (Richardson, 1991:78). When he travelled with his family he continued to record scenes in oils on cigar box lids.

Picasso's close friend Palares invited him to spend a holiday with him in his village, Horta de Ebro, a mountainous area, to assist with his recuperation after a bout of scarlet fever. He had been raised in seaside cities so he found life in the country a very pleasing experience. He helped out on the farm which belonged to Palares' parents. He looked after the domestic animals, cleaned out the stables and went for walks in the forest. He learned how to milk a cow, draw water from a well, look after chickens and horses, and all the usual daily activities which are a part of life in a rural village (Richardson, 1991).

Picasso and Palares spent a summer camped in the mountains. They spent their time sketching and painting. Picasso's father even sent a large roll of canvas and a stretcher for his son to use on the site. They:

> daubed the cave with paint, threw off their clothes and stayed naked. At night they slept on a huge bed of hay they had cut; they washed under a waterfall; they cooked the rice ... Painting things when not in use were bundled up in the safety of a tree (Richardson, 1991:103).

It seems that working in the open air in the rural countryside, encouraged Picasso to be experimental in his use of colour, form and imagination. When they returned to the village farm he worked hard producing images such as a horse fair, a wash house, the village smithy, a mill and a street scene. He was anxious to distance himself from the artistic influence of his father, so he refused to return to the Academy and decided instead to establish his own studio and teach himself to draw.

During his childhood, the Spanish surrealist artist Salvador Dali constantly looked forward to school holidays that he usually spent in Cadaques, which is a village situated on the Mediterranean coast of Spain. He loved to wander by himself on the beaches and rocky outcrops. He thought that the landscape he explored was the most beautiful in the world and he imagined how Leonardo would have been able to capture the dramatic rocky contours. The rocks and beaches of this landscape feature prominently in many of his works. 'My summers were wholly taken up with my body, myself and the landscape, and it was the landscape that I liked best ... for it is the most beautiful landscape in the world' (Dali, 1981:127).

Socialisation and artistic children

Studies by Dimmack (1974) and Dutton (1992) along with data from biographies and autobiographies about the early lives of well-known artists indicate that many artists considered themselves social 'outsiders' from an early age. In many instances the individuals experienced periods of debilitating illness which had necessitated their being isolated from other children for extended periods. In other instances the family home was geographically isolated and therefore only limited contact with a peer group was possible. In other cases, the artists had been raised as an only child.

Gallagher (1975:246) made the following statement about a characteristic of a creative individual 'is independent in attitiude and social behaviour. He does not follow the crowd nor is he swayed by the crowd, because he has a strong self concept and sense of personal identity.'

Getzels & Csikszentmihalyi (1976) interviewed some art students about their childhood experiences. One subject remembered that when he was about seven

his mother began work and was absent from the home for most of each day. During this time he was ill with measles and consequently he had to remain in bed alone for several days. His mother provided him with paper and paints. When he ran out of paper he painted the sheets and then the walls. According to Getzels & Csikszentmihalyi (1976:210),

> This early memory exemplifies one of the adaptive possibilities of visual expression. For a person who is lonely and helpless, the ability to create visual images is a sign that he exists, that he can change and control his environment.

Dimmack (1974) reports that Noel Counihan was a solitary, sensitive and introverted child. Counihan felt that he was different from other children and this perception contributed to his feelings of isolation and also to his artistic development. Drawing provided him with a means to invent and fantasise within a world of his own invention and thus provided a refuge from his difficult home environment.

According to Dutton (1992:98) Constance Stokes, like Counihan, was a shy child and indicated that she had an inferiority complex. She felt that the only thing she could do was to draw. Stokes said that she was terrified at school. 'I hid behind trees and I couldn't make friends but I lived from one week to the other for this art at school, you know, half an hour ... it was my salvation' (Dutton, 1992:98).

Oscar Kokoschka was the eldest child in his family and since the next youngest child died in early childhood, Kokoschka spent most of his first years as an only child (Kokoschka, 1974).

Leonardo was illegitimate and grew up in isolation as an only child. He was in his twenty fourth year when the first of his nine brothers and two sisters were born (Richter, 1980).

Warhol was a timid child who kept to himself and had few playmates. Warhol's childhood was interrupted by several debilitating illnesses. When he was two, his mother had to bathe his eyes daily because they had swollen so badly. When he was four he suffered a broken right arm when he fell on some street car tracks. At six he contracted scarlet fever and when he was eight he had rheumatic fever which had a major effect on his development. He was diagnosed with St. Vitus' dance and the doctor ordered him to remain in bed for a month. During this time Warhol was able to detach himself from the world. He was constantly entertained with movie magazines, comic books, cut-out paper dolls and colouring books. As well, his mother moved him into the dining room which was adjacent to the family kitchen and the family radio was also put in the dining room for his enjoyment.

During his childhood, Warhol suffered three breakdowns which have been referred to as Sydenham's chorea. The tremors of the face, arms and legs ensured that he remained inside, often in bed where he listened to the radio and played with his cut out paper dolls and scrap books which he spread out all over his bed.

Picasso had a period of ill health when he was young and spent quite a deal of time in solitude . He used this time for making drawings and paper cuts. Richardson (1991:102) cites a time when Picasso was recovering from scarlet fever, he sat up in bed and sketched the floor of his room with the domestic objects including a chamber pot. His sister cared for him during his illness and he made studies of her while he was recovering. Picasso used to draw constantly and he liked to be left alone, undisturbed, while he was involved in the process, as it was his favourite activity.

As a child, Dali was a 'loner' with few close friends. He was highly imaginative and spent much of his time at home in a world of fantasy which emphasised his separation from the usual life of a young boy. '... while taking my usual solitary walk I remember having savoured the beauty of each blade of grass' (Dali, 1981:11).

According to Maddox (1983:10) Dali preferred to be alone when he was painting. He enjoyed the solitude of his studio and he often made excuses which enabled him to withdraw and make art. In the simple studio '... he felt unique, living out his fantasies, playing at being a genius' (Maddox, 1983:10).

T. S. Eliot was often ill during his childhood. His mother took great care of him and he grew up surrounded by women including his mother, his sisters and several other female relatives. He particularly enjoyed reading and sailing alone on the Mississippi river near his childhood home.

H. G. Wells, the writer, suffered a broken leg when he was seven years old. At the time of his accident he had recently discovered the joys of reading so his parents provided him with a plentiful supply of reading materials as well as paper and pencils: 'My world began to expand very rapidly, and when presently I could put my foot down, the reading habit had got me securely' (Wells, 1934:77).

Roe, in her 1973 study of the making of a scientist, reported that many of her subjects had quite specific and fairly strong feelings of a personal isolation as children. Many of them had missed substantial periods of schooling due to illness (Roe, 1973:87), and indicated that they had felt different or apart from their peers in some way. One of the subjects stated: 'I was always lonesome, the other children didn't like me. I didn't have friends, I was always out of the group' (Roe, 1973:88).

Ellis (1904), who reported an investigation about creative individuals, wrote that the subjects had frequently experienced poor health during childhood which had led to their being isolated from their peers for varying periods.

According to the research of Gardner (1993a:90) Einstein often played alone even when there were other children around. He was generally a very quiet and thoughtful child. Stravinsky, the composer, was lonely as a child (Gardner, 1993a:191). He was uninterested in formal schooling and preferred to educate himself.

The research conducted by Freeman (1991:118) revealed that those subjects who were identified as 'Creatives' were more likely to be unhappy at school. Their discomfort was described by one of the subjects: 'One of my great grudges against the school is that they only like people who conform ... well I'm a bit different from other people ... I'm a bit of an extrovert and they don't like that.'

Andy, in a study by Freeman, reported:

> When I get to school, I've learned to isolate myself mentally from anything that might hurt me ... my music is a useful emotional outlet. I used to find it very frustrating that there wasn't anyone at school that I could really sit down and talk to ... I refused to conform (Freeman, 1991:47).

Another subject who was part of Freeman's study, and who decided to become a fashion designer at an early age, had only one friend when he was eleven, an eighteen year old boy.

For a number of subjects who participated in research conducted by Barron (1972), art school was the first school where they had felt comfortable. One subject indicated that she felt removed and isolated because she had nothing in common with her peers. Several of the male subjects felt removed from their peers because they were not interested in sports while some of the females felt that they were isolated because they were not concerned with the usual femimine subjects.

Technical knowledge

Gardner (1990b) claimed that art education has generally been viewed as a means of promoting self expression, creativity and imagination rather than as a craft to be mastered or as an area of study to be valued scholastically. Polanyi (1958:206) asserts that 'all arts are learned by intelligently imitating the way they are practised by other persons in whom the learner places his confidence.' The study of biographies and autobiographies of well-known artists reveals that most have used copying as a method of acquiring knowedge and skills about art techniques.

Cane (1951), recommended that children should study the art work of the masters, both old and new, to examine their methods and processes to assist them to work and develop their own skills and refine their techniques.

Noel Counihan enjoyed drawing and when he was only five or six years old, he copied the drawings of his older brother. Later, at secondary school he became totally involved in studying and copying the reproductions of the work of Leonardo. At fifteen, Counihan decided to become an artist (Dimmack, 1974).

During his childhood, Thomas Hart Benton drew battleships, even though he had not seen one. He acquired his visual knowledge about the ships from colourful posters advertising the navy, which were displayed in the shops of his town. He covered up his lack of knowledge of certain details of the ships by drawing explosions which were inspired by the style of print of the blowing up of the *Maine* which was very popular at the time. He was also inspired by a large, coloured lithograph of *Custer's Last Stand* , which was displayed in the local barber shop. As well, he was influenced by a book he had read which featured dramatic adventures of the first Caucasian hunters and pioneers who entered the Mississippi Valley, to draw images of American Indians (Benton, 1937).

When John Ruskin was about eleven, he spent a lot of time copying the works of other artists. The work of George Cruikshank was a particular attraction. Later, when he was fourteen, he copied the works of Rembrandt at the Louvre as well as imitating J.M.W Turner's landscape vignettes (Earland, 1910).

Eugene Delacroix loved to go to the Louvre with his uncle where he admired the famous works of art that had been brought to Paris by Napoleon. He especially admired the work of Rubens and Veronese. According to Deslandres (1963), Delacroix said that he became a painter:

> because of the orange hood on the shoulders of the servant on the left in Veronese's *Marriage of Cana* and because of the water-drops trickling down the backs of the naiads in Ruben's *Entry of Marie de Medici into Marseille* (Deslandres, 1963:11).

Later, Delacroix made a copy of Rubens' painting.

Augustus John indicated that the works of the Pre-Raphaelites, which he sometimes found reproduced in magazines, helped to inspire him with an intense interest in romanticism. He copied lithographs of Swiss scenery in three different coloured chalks but he also practised drawing from life using the work of the masters as models (John, 1954).

The writer D.H. Lawrence was also a very keen painter. He learnt to paint from copying other pictures, usually reproductions, sometimes even photographs. Ghiselin cites Lawrence as recalling:

> copying some perfectly worthless scene reproduced in some magazine. I worked with almost dry water-colour, stroke by stroke, covering half a square inch at a time, each square-inch perfect and completed, proceeding in a kind of mosaic advance, with no idea at all of laying on a broad wash (Ghiselin, 1955:70).

Lawrence would spend many hours in deep concentration making copies which gave him an enormous sense of achievement.

Richard Lee said that he was encouraged as a student to make copies of the works of the masters and that later, when he became a teacher, he encouraged others to copy. He indicated that it helps one to grasp, perceive (if only dimly sometimes) 'the language' of art (Drew & Harrison, 1988:42).

Similarly, John Lessore stated that his first loves were the artists of the Italian Renaissance period and that a particular favourite work of his was *Mercury Instructing Cupid before Venus* by Correggio (Drew & Harrison,1988:46).

Eisner (1991) described his experience in the arts as a young student of painting. He pointed out that solving problems in visual arts is just as much a cognitive process as problem solving in a discipline such as science. He stated:

> My work in the arts as a painter made it perfectly clear that cognition, by which I mean thinking and knowing, is not limited to linguistically mediated thought, that the business of making a picture 'that works' is an awesome cognitive challenge, and that those who limit knowing to science are naive about the arts and in the long run, injurious to the children whose educational programs were shaped by their ideals (Eisner, 1991:38).

From the age of nine, Picasso seems to have worked hard to develop and refine his understanding and control over colour, line, space and form. By the time he was thirteen, Picasso was using gouache, charcoal, conte, pencil, pen and ink,

watercolour as well as oil on canvas (Cirlot, 1972). In an interview with Apollinaire about 1910, Picasso indicated that the first pictures that he sold were to a convent in Barcelona when he was fifteen.

> The nuns had commissioned me to copy two altar pieces by Murillo; the idea bored me, so I copied them up to a point, then rearranged things according to my own ideas. Considering my age, I must admit feeling very satisfied (Picasso in Richardson, 1991:73).

When Picasso turned sixteen, he was accepted by the Royal Academy of San Fernando in Madrid. He painted autumn scenes in a park and made drawings using a very diverse range of styles; he often visited the Prado museum and copied the works of the great masters. He painted a copy of *Philip IV* by Velasquez and made sketches of the equestrian portrait of Philip IV. He was influenced by *modernisme*, which was a blend of symbolism, art nouveau and Jugendstil. For example, he stylised some of the forms and used a number of heavy outlines around them. Picasso also made some copies after Goya, sketches of animals including dogs, cats and horses, and dramatic scenes of bullfights, street fights and cafe life. Cirlot states that sketch books from this period (1897 and 1898): 'show two types of sketches, those drawn from life, which have an objective clarity of vision, tremendous vigour and great subtlety of drawing, and those springing from the imagination' (Cirlot, 1972:66).

A letter which Picasso wrote to a friend in Barcelona, provides some insights into his ideas about art at the age of sixteen : he distrusted art theory which promoted the concept of teaching drawing diagrammatically and 'dogmatic notions of pointillism'. He clearly states his preference for the work of El Greco and Velasquez rather than the more popular Murillo, whose work he had recently copied. Picasso relates that he was impressed by the work of Titian, Van Dyke, Rubens and Teniers. He also indicates his intention of doing a 'shocking' drawing.

Picasso continued to visit cafes and to paint landscapes with old buildings, shepherds and animals. Along with his teacher and some of his fellow pupils, he visited Toledo to paint a copy of El Greco's *Burial of Count Orgaz.* Picasso painted his copy as instructed but he then modified the work by giving the figures the faces of his teachers.

Dali sometimes copied from the images he had displayed on the walls of his studio. He made a copy of the *Venus of Milo* in clay. His father gave him a whole set of monographs about the old Masters. According to Dali this present:

> produced an effect on me that was one of the most decisive in my life. I came to know by heart all those pictures of the history of art, which have been familiar to me since my earliest childhood, for I would spend entire days contemplating them. The nudes attracted me above all else, and Ingre's *Golden Age* appeared to me the most beautiful picture in the world and I fell in love with the naked girl symbolising the fountain (Dali, 1981:71).

Wilson &Wilson (1982:27) documented in some detail the influence of imagery from the popular culture, often via the process of initially copying the images. Their research focused particularly on the work of children above the age of eight or nine, when the desire for realism in the images is particularly strong.

Access to art

Access to books with interesting imagery, reproductions of the work of Old Masters, viewing original art works in a gallery or on the wall of a home along with the availability of imagery from comics, television and other popular sources such as the movies, have been stimulating experiences for many artists during their childhood.

According to Bockris (1990), Andy Warhol was interested in movies and requested that his parents acquire a cartoon projector for him. At this time he was just seven years old. His mother began a job doing housework specifically to earn the money to buy the projector for her son. There was not sufficient money to purchase a screen so the images were projected on a wall of the house. Warhol watched cartoons featuring *Mickey Mouse* and *Little Orphan Annie* to get ideas for some of his drawings. In later years he earned an international reputation as a maker of avant garde movies.

Warhol's best friends were always girls and he began attending movies on Saturday afternoons. He collected publicity stills signed by the stars and he soon had a boxful of the stills which became the starting point of his collector's 'mania'. These stills were the same kind of photographs on which he based his silk screen portraits of the movie stars twenty years later. Warhol always indicated that his favourite film was the Disney cartoon classic *Alice in Wonderland.*

Warhol spent time cutting out photographs of movie stars from newspapers and magazines even before he began school. He created dozens of scrap books of his favourite stars including Joan Crawford, Bette Davis, Greta Garbo and Shirley Temple. His mother was not concerned about his lack of playmates

because he related to the film stars on screen and in his scrap books. After school he spent time cutting and pasting using a mixture of flour and water.

Over the space of about a year, while he was living at Corunna, Pablo Picasso produced some handwritten newspapers which he used to communicate with his family in Malaga. He based them on a popular weekly Spanish publication, *Blanco y Negro* and a journal about theatre, *Teatro Critico.* These newspapers included cartoons, caricatures, drawings of soldiers, dogs, children and young couples, comics and a record of day to day life in Corunna. He used pen, sepia and pencil to produce these papers (Richardson, 1991).

Pablo Picasso's father advised his son to study the reproductions of paintings by the artists of the Spanish Golden Age. A feature of this style are the dark colours including ochres, umbers and bituminous browns. Picasso continued to paint portraits of family members and friends. He also painted his pet dog, *Clipper.*

When he was thirteen, Picasso exhibited some of his paintings in the window of a furniture shop in Corunna. About this time, Don Jose left Corunna and moved to Barcelona. During the journey, they spent part of a day in Madrid and Picasso was taken for a visit to the Prado. This was the first time that he had actually seen original examples of great art works. Even though he was able to spend only a few hours at the gallery, he sketched some heads from two paintings by Velasquez. In fact Picasso retained his admiration for the work of Velasquez for most of his career. He painted oil sketches of harbour scenes, still-life, history painting, and nude studies of a male friend. He was influenced by the work of Whistler, whose paintings were widely reproduced.

While he was still only fifteen, Salvador Dali and his friends edited a publication called *Stadium* in which he wrote regular articles about the great

masters of painting including Goya, El Greco and Velasquez. *Stadium* was printed on packing paper (Maddox, 1983).

On the walls of the laundry studio, which his parents had provided as a studio space, Dali pinned up reproductions of the work of Renaissance masters, which he had torn from magazines, as well as his own paintings (Dali, 1981). Dali's family did not believe that he would be able to earn a living from his art. On the other hand they realised that it was useless trying to convince Dali so, as a compromise, they suggested that he should attend the School of Fine Art in Madrid, become a professor and use any free time to paint as he wished. He was accepted by the Academy, and at seventeen he left home and went to live in Madrid. He spent time at the Prado making sketches of some of the paintings in the style of the Cubists. He had discovered the work of Juan Gris, a Cubist master, and suddenly revolted against the Impressionist style. Instead of using the brilliant rainbow colours, he chose to use sienna, olive green, black and white. Although he disagreed with the teaching offered by the Academy, he worked hard, never missing a class (Maddox,1983).

There were no books in Noel Counihan's parents home, however, somehow a book appeared which contained some black and white reproductions of a Royal Academy exhibition which aroused Counihan's interest in art. At about the same time, a novel about Leonardo da Vinci had a powerful effect on him. A friend gave him a copy of *The Romance of Leonardo da Vinci* by Dmitri Merezhkovsky. Through reading the book, Counihan realised that art could be a very powerful means of communicating deeply felt ideas and beliefs (Dimmack, 1974).

School factors

A teacher

Although Noel Counihan achieved little success in the other subjects at school, he received praise and encouragement from his art teachers. When he was at secondary school, they recognised his talent for drawing and encouraged him to attend the National Gallery School in Melbourne (Dimmack, 1974).

A talk given by Charles Bush's art teacher in art class at secondary school, about the life and work of the artists Rembrandt and Turner, was the catalyst which helped him decide that he wanted to be an artist. He was thirteen years of age at the time (Hetherington, 1963).

At secondary school, Oscar Kokoschka had an art teacher who supported him and encouraged his interest and involvement with art. He told Kokoschka that he was 'a born artist' and he intervened on behalf of his student when there was a question of Kokoschka being admitted to a tertiary institution to study art (Kokoschka, 1974).

Andy Warhol's secondary school art teacher recognised his talent and endeavoured to help him overcome his shyness. She considered him to be a loner. His shyness was a defence because he thought he was a freak considering his pallor, the discolouration of his face and his white hair. His teacher encouraged Warhol to enter art competitions sponsored by the *Scholastic Magazine.* Warhol was particularly good at line drawing but he rarely used colour in his work (Bockris, 1990).

'A substantial number' of the subjects in the study by Howe & Sloboda (1991:55 of the early lives of musicians, 'spoke of at least one teacher with the kind of admiration that can only be earned by a person who genuinely cares and can truly inspire.'

H.G. Wells wrote that when he was nine, he attended a small school run by a Scotsman named Thomas Morely. When Morely realised that Wells was a very keen and highly motivated student, he provided as much encouragement and help as was possible (Wells, 1934).

Gustin's mathematical subject identified a significant mathematics teacher he encountered when he was in the ninth grade. The teacher was a member of a group which was preparing a program in modern mathematics. At the beginning of the year he had ambitions to become an electrical engineer, but because of the influence of this significant teacher, by the end of the school year he had decided that he really wanted to be a mathematician (Gustin, 1984:341).

Special art classes

Leonardo da Vinci developed his own style of drawing and he modelled heads of smiling women and children in clay. He experimented and played with the 'new game' of perspective. When he was sixteen, his father took him to Florence and showed some of Leonardo's sketches to Andrea del Verrocchio who was well known as one of the most highly esteemed instructors in every branch of the arts. He was a goldsmith, a sculptor and a painter. His busy studio produced paintings, sculpture, and various other objects such as tournament shields and ceremonial helmets. Leonardo was accepted into the studio as an apprentice. Verrocchio introduced Leonardo to medicine, astronomy, geology and mechanics. Involvement in so wide a variety of tasks no doubt stimulated Leonardo's natural curiosity, just as it must have encouraged his versatility (Vasari, 1965).

> In that inestimable folio of drawings, once in the possession of Vasari, were certain designs by Verrocchio, faces of such impressive beauty that Leonardo in his boyhood copied them many times. (Pater, 1963:6).

As a child Treania Smith had some special drawing lessons, and her father, who was a great friend of Max Meldrum, took her to Meldrum's studio. She said that: 'I fell in love with the sort of real studio life that I thought I could see there' (Dutton, 1992:84).

Eisner (1991) contended that the visual arts were a salvation for him in the two primary schools he attended. He was good at art; in fact he was known as the 'class artist'. His grade three teacher recognised his talent and suggested to his mother that Elliot should be enrolled in special art classes at the School of the Chicago Art Institute. Since his mother valued the arts, she enrolled him in the Saturday morning art classes and he continued to attend (while he was at primary school) until he began secondary school (Eisner, 1991).

From 1914 until 1918, Dali studied at the local state school but later he transferred to the Marist Brothers Academy at Figueras. According to the literature about his schooling (Maddox, 1983) he was a show-off and anti-social in his behaviour. He failed to do well in school. While he was at school, he lived in a world of fantasy and day-dreams. In his autobiographical writing, Dali (1981:64) reflected on some oil paintings which decorated the corridor near his school room: 'From my seat I could see two of them distinctly: one represented a fox's head emerging from a cavern, carrying a dead goose dangling from its jaws; the other was a copy of Millet's *Angelus.*' He also referred to a crucifix which stood on the teacher's table at the front of the school room:

> The feet of the Christ were dirty with a sickening grey produced by the daily contact of the children's fingers, for after having kissed our superior's hairy hand and before crossing ourselves as we left, each one of us had to touch the pierced feet of the Christ with his ink-blackened fingers (Dali, 1981:64).

During 1918-1919, his parents, wanting to support Dali because of his talent and intense interest in art making, sent him to Pepito Pitchot, who was a friend of theirs. Pitchot had a brother, Ramon, who lived in Paris. He was a gifted painter who worked in the style of the Impressionists. Dali lived in a very creative environment. The walls of many of the rooms were hung with Impressionistic oil paintings and coloured etchings by Ramon Pitchot, which influenced Dali's way of looking at the world around him.

> I squeezed from these pictures all the literary residue of 1900, the eroticism of which burned deep in my throat like a drop of Armagnac swallowed the wrong way. I remember especially a dancer of the Bal Tabarin dressing. Her face was perversely naive and she had red hairs under her arms.
> ... the paintings that filled me with the greatest wonder were the most recent ones, in which deliquescent impressionism ended in certain canvases by frankly adopting in an almost uniform manner the *pointilliste* formula. The systematic juxtaposition of orange and violet produced in me a kind of illusion and sentimental joy like that which I had always experienced in looking at objects through a prism, which edged them with colours of the rainbow. There happened to be in the dining room a crystal carafe stopper, through which everything became 'impressionistic'. Often I would carry this stopper in my pocket to observe the scene through the crystal and see it 'impressionistically'(Dali, 1981:81).

Two of Pepito Pitchot's sons were musicians, one daughter was married to a poet and another was an opera singer. At Pitchot's, Dali was given a large white-washed room to use as a studio where he produced many works.

> I had set up a big box of oil colours on a large table where each day a pile of drawings would accumulate. The walls too, before long, were soon filled with my paintings which I put up with thumb tacks as soon as they were finished (Dali, 1981:82).

Pitchot encouraged Dali's father to enrol him in a class in Figueras run by Senor Nunez. He received individual attention from Nunez and he again studied the paintings of the great Renaissance masters. Dali was very impressed by an original engraving by Rembrandt which Nunez owned. Although Dali exhibited eccentric behaviour, he was a dedicated pupil. He investigated the use of chiaroscuro while studying with Nunez and he began to read widely on his favourite subject which was philosophy. Nietzsche, Voltaire and Kant were his favourite writers at that time. Even at this stage (he was fifteen years old) his paintings were beginning to attract attention and he was invited to exhibit his paintings in local and regional shows (Maddox, 1983).

While at primary school, Warhol was selected to attend free Saturday art classes held at the Carnegie Museum. Children from grades five through to ten who were identified as gifted and talented in art were chosen by their teachers to attend these special drawing classes. One of the teachers who taught at these special classes noted that Warhol's work was individual, unique and original right from the beginning (Guiles, 1989:15).

To earn extra money to purchase art materials, Warhol assisted his brother in his business of selling fruit and vegetables door to door from an old truck. He carried a sketch book with him around the neighbourhood. He used a speed sketching technique which he had learned at Saturday morning art class. He

would put the pencil on the sheet of paper and draw a figure or object in ten seconds without removing the pencil from the paper. He drew what he saw, people standing in doorways or gathered around the truck (Bockris, 1990:38).

When Picasso was eleven and at secondary school, he was accepted into his father's ornamental drawing class. In this class, he did drawings of plaster casts and drawing by rote. Despite the rigid rules of his father's drawing classes, Picasso's drawing skills developed rapidly. Through his friendship with the painter and sculptor Isidora Modesto Brocos, he developed an interest in the use of watercolour. It is also likely that Brocos helped him with his drawing technique. He used conte crayon as well as charcoal. According to Richardson (1991:45):

> Compared with his academic exercises the drawings that Pablo did for his own pleasure are not particularly skilful - naive in conception, faulty in scale, clumsy in execution - but they abound in boyish fantasy and high spirits.

Even though Picasso was just thirteen, he was accepted into the School of Fine Arts at Barcelona, where his father was employed. Picasso respected the director's advice that students should draw, and draw from the model. All the models at the art school were male. When he went home in the evening he had his father or sister to pose for him. Otherwise he would use the mirror to make self portraits. He made many copies of female nudes in the Museo del Establecimiento. Don Jose encouraged his son to begin making religious works as he believed that he could earn a profitable income doing so. For these works, Picasso made numerous preliminary drawings.

Children have often been provided with opportunities to attend special classes because of the influence and awareness of a teacher. Freeman cites a case study (in Howe, 1993:93) from personal research where a child of poor Irish immigrants was selected by her teacher to audition for special music classes because she sang sweetly and who has now become a concert artist.

Summary

Recognised practising artists have artistic abilities that are inherent but which require nurturing or may be affected by environmental, family or social influences. Environmental factors seem to nurture the artistic characteristics of individuals toward the realisation of a career as an artist. Studies which scrutinise the lives of well-known artists serve to reveal factors which impact on the career development of artists.

A review of the literature, dealing with the major assumptions of the research gleaned from the biographies and autobiographies of historical artists was included in this chapter. The main factors of influence identified from the literature were used to present the information under the following headings: inherent artistic ability, familial factors including the family environment, socialisation, technical knowledge, access to art, and school influences. Chapter three will focus on the methodology used for the study.

Chapter 3

Methodology

Purpose of the study

The purpose of the study was to investigate the childhood experiences of contemporary, recognised visual artists in order to document and identify formative influences which nurtured their interest in visual art through childhood into mature professional development.

In this chapter, the following will be described: the type of research which was conducted, the specific research design, the selection of the subjects, the development of the interview schedule, interview procedures, conduct of the interviews and the process of recording the data.

Seeking permission to conduct the study.

Permission to conduct the research was obtained from the University of Tasmania Ethics Committee (Human Experimentation). A letter was distributed to all potential subjects stating the purpose of the research and requesting permission to be participants in the study (Appendix A). The

researcher informed the Ethics Committee of the research proposal. The following documentation was supplied to the Ethics Committee:

a. A copy of the form: *Application to undertake an investigation involving human subjects* .
   Included in this information were:
   i. the aims of the research;
   ii. justification for the research;
   iii. a brief description of the planned investigation.

b. A copy of the interview schedule.

c. A copy of the letter designed by the writer to invite artists to participate in the research (Appendix A).

d. A copy of the agreement for the artists who agreed to be subjects for the research to sign (Appendix D).

This agreement indicated that the subject had read the information supplied which described the research. The agreement included a statement that the subjects approved that the data gathered for the study could be published provided that they could not be identified as a subject. The subjects were assured that the taped interviews would remain strictly confidential, that the tapes would be stored securely in a locked filing cabinet at the University and that the contents would be available only to the investigators and the relevant participants.

Target Population

Subjects for the research were selected from lists of artists kept by Tasmanian commercial galleries and local government-funded regional galleries who exhibit their work on a regular basis.

Meetings were arranged with the staff of the Queen Victoria Museum and Art Gallery, the Director of Gallery Two and Director of the Design Centre of Tasmania, Launceston to acquire lists of artists who had exhibited works in their gallery spaces.

A total of thirty four artists were interviewed in the study. All subjects were residents of Tasmania. There were seventeen males and seventeen females. They were drawn from six media areas: painting, print making, ceramics, textiles, sculpture and book illustrating. The structure of the sample is represented in Table 1.

Table 1

The structure of the sample: media areas represented by the participants
N=34

Media Areas

	Painting	Printmaking	Ceramics	Illustration	Textiles	Sculpture	Total
Male	5	2	2	4	2	2	17
Female	6	2	3	1	3	2	17

As stated by Chadwick, Bahr & Albrecht (1984:69), it is generally agreed that 'results from the studies of samples will accurately represent the wider populations from which the samples are drawn.'

Organisation of interviews

Letters were written to subjects selected for the study (Appendix A). As artists responded indicating agreement to be interviewed, follow up phone calls were made in order to thank them and arrange details of the interview (Appendix B). Suitable times were arranged and venues agreed upon. This information was also confirmed in a letter which accompanied a copy of the interview schedule (Appendix C).

The majority of the respondents preferred to be interviewed in their own home or studio, while a small number asked to be interviewed at the University. Some of the subjects, who lived in Launceston, came to the researcher's home for the interview. In each instance it was made clear that it was essential that they felt comfortable and relaxed for the interview as it was necessary for them to recall events from the past in response to most of the questions that they would be asked during the course of the interview. Where possible, when the subjects lived in close proximity, two or three interviews were organised on a particular day. The researcher made a phone call to each of the subjects close to the time of the planned interview to confirm arrangements and to respond to any queries which may have arisen regarding the content of the interview schedule.

Data-gathering approach

Naturalistic research was deemed to be an appropriate methodology for this study. The qualitative process of inductive analysis was used to generate information about significant influences on the development of young artists. According to Patton (1982:40) inductive analysis is a research method based on inductive reasoning. He has described the objective of this approach by writing:

> A qualitative research strategy is inductive in that the researcher attempts to make sense of the situation without imposing pre-existing expectations on the research setting. Qualitative designs begin with specific observations and build toward general patterns.

The two main types of survey methods are: the questionnaire and the interview. According to Chadwick, Bahr & Albrecht, (1984:101), one of the advantages of survey methods of research is that they enable the researcher to obtain information about past events. Subjects can be questioned about such issues as their childhood experiences, their family background and their participation in various educational, social or religious activities. The use of survey research methods was ideally suited to this project.

Interview methodology

Interviews are relevant data-gathering tools for inductive inquiry.

Kahn & Cannell (1957: 16) have defined a research interview thus:

> a two-person conversation, initiated by the interviewer for the specific purpose of obtaining research-relevant information, and focused by him on content specified by research objectives of systematic description, prediction and explanation.

An interview is a method of data collection which relies on some interaction between the interviewer and the interviewee. The purpose of an interview is to collect data which is valid and reliable. According to Marshall & Rossman (1989:82) it is essential that the researcher provides the subject with the clear message that the information being gathered is valuable and appropriate. There is also the possibility of follow-up interviews being conducted to clarify and validate particular information collected at the initial interview.

According to Worthington (1982:1) interviews can be used for the collection of complex and personal data. It is essential to consider that the data gleaned from the interview process is based on the information the subjects say they know, remember, believe or think, not what they actually know or believe. In many instances, the differences are slight. However this issue is a significant consideration when the researcher attempts to draw conclusions from the interview material.

Cohen & Manion (1994:309) have identified four types of interview that are appropriate for conducting research: the structured interview; the unstructured interview; the non-directive interview; and the focussed interview.

Dexter (1970); Richardson, Dohrenwend & Klein (1965) along with Merton, Fiske & Kendall (1956) have all concluded that structured interviews are sometimes referred to as 'focussed' interviews while unstructured interviews can be referred to as 'elite', 'specialised' or 'exploratory' interviews.

According to Lincoln & Guba (1985:154) interviewing, in particular the unstructured interview, is the 'backbone of field and naturalistic research'. Dexter (1970), developed new ideas for the scholarly analysis of interviews from an anthropological standpoint which he defined as elite and specialised interviewing.

Structured interviews are employed by researchers who perceive the subjects in a sample to be of equal importance and where the questions are identical. According to Minichiello et al. (1990:92) an unstructured interview relies on the social interaction between the interviewer and the informant and dispenses with formal interview schedules.

A semi-structured interview is designed to include a mix of both stuctured and unstructured models in that there are set questions but the interview is allowed to flow according to the specific interests of the subject. Minichiello et al. (1990:92) suggest that with semi-structured interviews, the topic area guides the questions but the mode of questioning is similar to the process employed for unstructured interviews.

Patton (1982:162) identifies three basic approaches to interviewing: the informal, 'conversational interview'; the 'general interview guide' approach, and the 'standardised, open-ended interview.' The strength of the conversational interview is that the interviewer is able to respond to the individual differences and situational changes with each subject. However it often requires a great deal of time and multiple interviews to obtain systematic information. An interview guide provides a checklist of topics and subjects which the interviewer is able to adapt during the course of the interview. Thus the interviewer is able to make certain that all issues determined in advance have been discussed with the interviewee and provide greater flexibility. The standardised, open-ended interview provides a series of carefully devised and

sequenced questions which ensures that each subject of the study is asked the same questions using the same words (Patton, 1982:164).

Bogdan & Taylor (1984) contended that in-depth interviewing is a non-directive, unstructured, non-standardised, and open-ended technique. Douglas (1985) coined the phrase 'creative interviewing' which he attributes to the non-directive method of psychotherapist Carl Rogers.

Four problems were identified by Douglas (1976:57) for a researcher using interviews to collect research data: evasions, misinformation, lies and 'fronts'. He has advised interviewers that human reality is complex and sometimes protected by layers of 'presentational frontwork' (Douglas, 1985:150).

Hetherington profiled 40 Australian painters (Hetherington, 1963). These profiles (with one exception) were transcribed from interviews. Some of the subjects referred to their childhood experiences. Information relevant to the questions addressed in this research was identified in Hetherington's study.

Rodman documented interviews which he conducted with some well known American artists. Rodman, like de Berg and Hetherington, conducted the interviews personally. Often the interviews were recorded in the home or studio of the artist. In Rodman's case, he did not use a tape recorder. He conducted unstructured conversations with his subjects and in almost every instance, he:

> took more than notes—a word-for-word transcription of actual phrases and sentences, often whole paragraphs—with the conviction that the actual phraseology employed is as much a clue to the person interviewed as what he or she actually says. (Rodman, 1957:xxi)

A key informant is an individual who provides information through conversations, informal verbal interchanges and formal interviews (Gilchrist,

1992). A key informant is a person who possesses special knowledge and status in a field of expertise and is willing to share the knowledge and skills with the researcher (Goetz & LeCompte, 1984).

Key informants are not selected randomly. Johnson (1990:24) described how key informants are selected, who they are and how the relationship with the observer can develop. He provided two sets of criteria which should be used sequentially to locate key informants. The first set of criteria is 'theory driven' and is developed with the theoretical knowledge of the researcher in the construction of the research instrument. Johnson refers to the second set of criteria as 'data driven' which results from the nature of the information derived from initial contact with the potential informants which identify them as experts in their particular field. The first set of criteria provides a 'pool of potential key informants'. The researcher then contacts the subjects who are willing to work with the researcher which is the second criterion identified by Johnson.

According to Gilchrist, 'Sometimes good key informants are acquired serendipitiously, and thus only selection two criteria are considered' (Gilchrist, 1992:80).

Van Manen (1990), has cautioned qualitative researchers using unstructured conversational interviews to be sure of the reason or main questions for the interview. He advised that before beginning an interview schedule, the researcher needs to be firmly oriented to the questions at the centre of the research so that the interviews do not lose direction and consequently produce useless data (Van Manen, 1990:66).

Douglas, Roberts & Thompson (1988:53), pointed out that for the conduct of interviews the equipment required and how each item works could be an influencing factor for conducting successful interviews. Also provided was

information about structuring an interview schedule. The authors claimed that a researcher should follow a predetermined pattern (either a list of general questions or a more detailed schedule) which can be used flexibly, allowing the informant to digress to topics not already on the interview schedule. Using this approach, a researcher would be able to direct the course of the interview and at the same time provide the informant with adequate latitude for spontaneous discussion. As stated by Douglas et al. it is not possible for researchers to 'predict the amount or character of information stored in the memory of an individual.'

Douglas et al. (1988) provided a checklist for use in conducting a successful interview. Items included: creating the best environment, sitting comfortably, arranging the equipment, checking the time at the start of the taping, checking that the recorder is actually recording, keeping an eye on the tape to check that the tape is not going to run out and interrupt the flow of the interview, making a note of any proper names or words that may provide a difficulty when it is time to transcribe the interview.

Wolcott (1990b:127) referred to a need to 'satisfy the implicit challenge of validity' when involved in the process of collecting and recording research data. Wolcott followed a sequence from the early stages of fieldwork, when the focus is the collection of information, through to the subsequent stages that concentrate on the processes of analysis and writing. Wolcott suggested that it is important not to rush fieldwork and to begin writing a rough draft soon after the process of gathering information from the field begins (Wolcott, 1990a:67).

Wolcott (1990a:69) stated that he 'tries to report what he observes and to offer the reader an informed interpretation of the observations', whether they are his own or someone else's. He pointed out that it is important to remind the reader that data sources are limited and that the subject may not have been provided absolutely correct information either.

While Wolcott opted for subjectivity rather than detached objectivity as a strength of qualitative research, he pointed out that it is important to clearly differentiate between revealing one's own feelings and imposing value judgements. Wolcott advised researchers to use a continuous process of inviting one or more people to read the working drafts of the manuscript. The individuals who agree to help out in this way can check some of the following aspects: correctness, completeness, style and sequence, the suitability of analytical concepts, sensitivity to the people involved and the adequacy and appropriateness of interpretations made about the data.

Riley (1990), reported strategies for the commencement of data analysis. Information about organising the data and the analysis of hard copy using highlighter pens, and hand written categorising and coding was practical and appropriate for the research questions identified by the writer.

Administration of interviews

The interview schedule was sent to the subjects well ahead of time. Over the 'phone, the researcher encouraged the subjects to read through the questions on the schedule as soon as possible and to begin by jotting down notes of memories as soon as they could, so that on the day of the interview, the pressure to remember details about their childhood would not be so great.

Subjects were informed that the interview would take approximately one hour but for them to allow a two hour block of time to provide sufficient time for the researcher to set up the equipment.

Equipment used for semi-structured interview

A good quality portable cassette tape recorder and a microphone designed for use at meetings so the entire conversation would be recorded clearly were used for the interviews. Cassette audio tapes of 120 minutes capacity were used to avoid having unnecessary interruptions to the interview process by having to change tapes. At least two thirds of the interviews exceeded the one hour so it was also an advantage to have the 2 hour tapes to avoid having a proliferation of cassettes. The interviews were conducted over a period of ten months from May 1993 through to and including February 1994.

Designing questions for the study

Questions to be included in an interview need to be carefully devised and delivered since they can impact on information obtained from the informants. Minichiello et al. (1990:121) specified four kinds of questions: 'descriptive', 'structural', 'contrasting' and 'probing'. Spradley (1979) and Taylor & Bogdan (1984) have described descriptive questions as a non-threatening strategy often used to begin interviews. Burgess (1984) explained that structural questions are employed to investigate how informants organise their knowledge. Contrasting questions enable the informants to make comparisons of situations or events (Minichiello et al. 1990:220).

According to Kahn & Cannell (1957), notwithstanding the fact that a researcher has worded the questions carefully, the initial response from a subject may seem to be inadequate or incomplete. Kahn & Cannell defined the function of probing: 'to obtain full and accurate responses.' The researcher included a

number of probe questions during the interviews to respond to this problem identified by Kahn & Cannell.

Chadwick, Bahr & Albrecht (1984:118) suggested that in an interview 'it is almost always necessary to buttress central questions with supplementary probes which guarantee ... that ... respondents will provide the essential minimum of detail.'

The interview schedule was designed in a chronological sequence beginning with before school experiences and following through primary school and secondary school. Each subject had their copy of the schedule with them during the interview. Probe questions were developed for use with each of the questions in the schedule forwarded to the subjects. Probe questions were used at all interviews. Each subject was informed well before the interview that probe questions would be used with their permission. All subjects accepted the strategic use of the probe questions.

Three areas were identified as being the basis of the interview schedule—art experiences at home, art experiences at school and art experiences at different phases through childhood. Nineteen questions were designed for use in the interviews plus three questions relating to contemporary involvement in art. Three questions related to pre-school years, six questions related to primary school years and ten questions related to secondary school years. Of these nineteen questions five asked about art expression in school and seven asked questions about non-school art experiences. Of the nineteen questions, nine asked about art history and appreciation and ten asked about studio practice.

Trialing the questions

An artist outside the sample agreed to participate in the study as a trial subject. The subject was forwarded a copy of the interview schedule two weeks before the planned meeting for the trial interview. The trial interview was recorded on audio tape and subsequently transcribed. This trialing of the interview questions enabled the researcher to reflect on the clarity and appropriateness of the questions as well as to consider any areas of omission in the questions included in the schedule.

Modification of the questions

As a result of conducting the trialing of the questions, two of the original questions were deleted since they were deemed to be repetitive. A more extensive list of probe questions was developed to add to the breadth of information being sought by the researcher and to add to the specificity of the questions.

Organisation of interviews

Questions were sent to subjects in advance of the interview. This was in order to give the subjects time to think about and reflect on the questions. It was assumed that this method actively helped to increase the potential validity of

the responses given at the interview due to the time given for reflection. This strategy was very important for this particular study as data gathered relied on reminiscences.

Although the interview schedule was designed in a chronological sequence of questions, it was made clear to the subjects that they could follow through an idea or a memory even though it might skip from one period in their childhood to another. Permission was sought and given in all cases for interviews to be tape recorded. Subjects were informed that transcripts would be made and data transferred to a computer base but that all material would be kept strictly confidential by the researcher in that individual responses would not be able to be identified.

Subjects were encouraged to make connections with their thoughts and ideas which were appropriate for them at the time of the interview. The researcher kept track of the questions to which they had responded, and when they had completed a particular response, sequence of events or memory/thought patterns, the researcher returned to the unanswered questions. This strategy worked well as it allowed the subjects to be totally relaxed and not worry whether they had forgotten some significant event.

As interviews were completed, the researcher checked them to be sure that the information had recorded successfully. The tapes were then labelled and dated and stored in a locked metal filing cabinet in the researcher's office, until he was in a position to begin the process of transcribing them. The tabs on the side of each tape were removed to prevent the accidental erasure of the interview.

Selecting the data analysis tool

NUD.IST

NUD.IST is the acronym for 'Non-numerical Unstructured Data Indexing, Searching and Theorising.' NUD.IST is a computer software system developed by a research team based at Latrobe University, Melbourne, Australia. The program was specifically developed 'for managing and organising and supporting research in "qualitative data analysis" projects.' (Richards, Richards, McGalliard & Sharrock, 1992:2).

NUD.IST was deemed appropriate for data analysis for the following requirements of this research:

a. Collecting and recording the transcripts of the tape recorded interviews.

b. Indexing elements of the data under various categories.

c. Locating specific words and phrases in the text of the documents.

d. Using an index as well as searching the text to locate specific passages of text and the ideas in them.

e. Adding notes and comments about the ideas and themes as they emerge from the developing project.

f. Extending and modifying the indexing system as the research develops.

Using data in the form of text, NUD.IST enables a researcher to label units of text with codes which have been previously numbered. The developers of NUD.IST prefer to use the term 'indexing' rather than 'coding' (Richards & Richards, 1991). The facility offered by NUD.IST which was particularly appropriate for the analysis of the data collected for this research was the ability of the program to cut and paste the collected data under themes, ideas, topics or subjects.

A researcher can use NUD.IST software to index and explore the indexed items of any unstructured text, whether on-line (typed in) or off-line (stored elsewhere). Examples of off-line data which can be indexed are photographs, field notes, tables, videotapes and music. Sections of the content of such off-line data can be nominated and indexed (Burroughs-Lange & Lange, 1994). According to Burroughs-Lange & Lange their use of NUD.IST supported the claims that:

> the mechanics of field research are less likely to get in the way of analytical processes; the researchers' mental and creative energies were more directed towards analytical concerns; new data was easily integrated with already coded (indexed) material; theoretical 'play' was often productive, always easily accomplished and was without risk to important outcomes if it proved to be a 'blind alley'; an audit trail of the analytical process was always available through NUD.IST at any stage of the research process; answers to pre-existing questions and emerging theories were always grounded in the data with NUD.IST providing rapid retrieval of textual evidence; NUD.IST supported the generation and testing of grounded theory about the phenomena (Burroughs-Lange & Lange, 1994:15).

Trialing the data analysis method

The data collected at the trialing of the questions was transcribed using the Macintosh Word 5 computer program which was appropriate to convert to the text style required (Courier) for the use of NUD.IST. A number of key words

and phrases, relating to the factors which could be defined as characteristics of "nurture" of individuals toward the realisation of a career as an artist, were applied to the data. The trial of the program was successful and confirmed the researchers' assumption that NUD.IST would perform the major task of identifying and collecting relevant sentences and paragraphs from the transcribed interviews and so categorise the data.

Data collation

The taped interviews were transcribed by the researcher and then converted to a suitable font style and size to be accepted by the NUD.IST program (Appendix F). The data was indexed and categorised using NUD.IST. Chapter four reports the analysis of the data in detail.

Chapter 4

Results

The purpose of the study was to investigate the childhood experiences of contemporary, recognised visual artists in order to document and identify formative influences which nurtured their interest in visual art through childhood into mature professional development.

The study involved the researcher in conducting interviews with 34 artists residing in Tasmania. The interviews were taped on audio-cassettes and these were then transcribed. The transcriptions were analysed using NUD.IST. From this analysis, 21 categories were generated and identified.

The data will be reported under the following groupings which were identified as the significant themes in the literature as presented in Chapter two.

1. Inherent ability
2. Familial influences
3. Access to imagery
4. Technical knowledge
5. Socialisation
6. School influences

Table 2

The categories identified from the research data and the literature and organised according to groups

Groups	Categories
1) Inherent ability	a) Inherent ability
	b) Perseverance
2) Familial factors	c) Parents and grandparents
	d) The environment
	e) A significant other
	f) Religious imagery
	g) Collections
3) Access to imagery	h) Popular culture
	i) Books
	j) Museums and art galleries
4) Technical knowledge	k) Copying
	l) The influence of an artist
5) Socialisation	m) Isolation
	n) An outsider
	o) An artist as a role model
6) School influences	p) A teacher
	q) Social contacts at school
	r) Project work
	s) The art room
	t) Special art classes
	u) Prizes and awards

Table 3

The number and percentage of responses for each category
N= 34

Groups	Categories	Responses	%
1) Inherent ability	a) Inherent ability	31	91
	b) Perseverance	25	73
2) Familial factors	c) Parents and grandparents	33	94
	d) The environment	32	94
	e) A significant other	28	83
	f) Religious imagery	12	35
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Group 1. Inherent ability

Category a : Inherent ability.

This category refers to the ability to draw and paint with ease and confidence from an early age. Thirty one of the thirty four participants indicated that they had a particular interest in art making at an early age. Several indicated during the interview process that they could not recall a time when they had not made art of some kind. In most instances their interest was manifested in an ability, during early childhood, to communicate ideas in visual form. Drawing with the most readily available media was the usual method adopted by the subjects.

Subjects responded as indicated in the following examples:

> I always wanted to be an artist. I always wanted to make art. I always spent so much time painting and drawing and making things ... it was the thing I liked doing.
>
> For as long as I can remember, I have always done drawings of planes, ships and battles and I got a lot of pleasure from doing them .... I seemed to be good at drawing and making art.
>
> There's the drive to do it [make art] and I don't know where that comes from .... I didn't have contact with anybody that I could identify as an artist.
>
> My mother kept them [drawings] because I think they were fairly advanced ... they were drawings of birds and the landscape that we looked out on. We looked over the sea and I drew headlands and whales .... I got encouraged because of the skills I had ... and I don't remember them [siblings] having those skills or being encouraged. A fuss was made about some of the things I produced and I remember mum and dad talking to their friends and showing them some of the stuff [art work] that I had done.
>
> I used to do drawing and I was encouraged to do it ... I always felt that it was just something that you did.

> My family all said I was a very clever child .... I was always referred to as being talented at art making.
>
> I can't remember when I didn't draw. I always remember doing drawings.
>
> We had lots of paper so we'd just do one drawing after another. My sister and I both used to draw. Those memories are still very strong: sitting and drawing.

Nine of the subjects also reported their engagement in imaginative play which often included the use of natural materials such as mud or sand. Some examples of responses concerning imaginative play are as follows:

> My parents had a shack ... we always drew on the beach and made things out of sand. ... I went to kindergarten and we painted there and I can remember the teacher bringing in my mother to show her something that I had painted which I thought was rather special ... the teacher said wonderful things about this painting.
>
> I liked to make marks in the dirt in the garden and once a year when I went to the beach I used to like drawing in the sand. From an early age I enjoyed the process of drawing.

Half of the subjects remembered having had their artistic talents recognised at school. Although several had felt inadequate in some of the other curriculum areas, their ability to make art had provided them with a means to gain recognition from teachers and their peers. Some typical responses relating to such recognition are:

> The illustrations that I used to do in my books were highly regarded. They used to haul me to the front sitting in the front row and open all of my books to the pages where I had done the illustrations [for the inspectors] ... a feature was made of it and I remember that giving an impression like I was being pinpointed as having the skills in a particular area.
>
> I was good at [drawing] figures. Other children used to come and have a look when I was doing this sort of thing so I knew that I was good at it.
>
> I used to live for - wait for the times when we could use plasticine but I never made three dimensional plasticine, I was praised on my first day at school for making a picture with plasticine - long lines of plasticine and I made a flat picture.
>
> I was getting a lot of positive feedback from school from very early on ... it was a great honour to go up to Grade six [from Grade three] and draw the reindeer around the blackboard ... and I can remember so clearly discoveries like how to make fence posts vertical when I was drawing the mountains from the class room window.

My artistic skills were recognised while I was at primary school .... I can remember being told that I was a gifted child when I was in Grade 4.

Without fail every week we would be called out the front of the class room to show our (art) work. I don't know what the other children thought of it because we were always asked to go up the front to show our work and we were recognised as being very good at art.

Later in primary school I can remember beginning to find I could make a world in which I experienced things very deeply and that was through making pictures.

Primary school wasn't easy for me ... the only classes I remember loving were drawing .... I can still remember some drawings that I did but they were pretty zany .... I remember the headmaster saying that I should go into the creative arts.

At school, drawing was something that I enjoyed, that I could do naturally and art was something that was automatically going to come my way.

I filled my mother's books with drawings. She only had a few books but I had read them all by the time I was ten. And you know the end papers - they were covered in drawings. I drew people, figures, faces. My sister drew too. We were so interested in this - why, I don't know. I don't know where it came from or who told us about it because all I wanted to do was put colour on paper.

One of the things that stands out most in my mind was that I became very interested in embroidery. And I achieved a sort of reputation for myself in primary school because I used to embroider pictures, I used to draw pictures and I remember I did one of the playground scene of children doing all things you do in a playground, jumping and skipping and all those sorts of things and I just embroidered around in back stitch. But I can remember them making an impact on my teachers and my feeling that I have done something really fantastic. And I am sure they were works of art and they would have taken ages.

I do remember at some stage at high school naturally doing contour drawings. I could look at something and draw it exactly. I had a phenomenal ability just to draw and that was one of the things that made me think that I was going to be an artist, but I recognise now that there is a lot of truth in the left/right hemisphere theories and I was just simply tapping in to that ability. I know that at that stage it was not anything special to me that I could draw. It was remarkable to me that other people couldn't. It never seemed special to me. It seemed special to everyone else but when you think about it, it's nothing special, it's just that others couldn't do it.

I remember making incredible paper models. I used to design them myself, draw them and cut them out. They were 3-D models of ocean liners, trains and buses. I was more creative then than I am now.

Another thing I reckon that has helped me a lot, and let other people think that I could draw, was the fact that I had an understanding of perspective at an early age. I wasn't brilliant, but I could draw a box and knew why.

Category b : Perseverance.

This category refers to the determination and perseverance that subjects directed towards the activity of making art. Twenty five of the thirty four subjects made references to their approach to art-making which indicated that they adopted an attitude of perseverance because they were so committed to the idea of wanting to be an artist from an early age. The subjects had an overwhelming desire to acquire the knowledge and skills about various art-making techniques and so enable them to interpret their understanding of the world around them in visual form. Some typical examples of perseverance are as follows:

> I worked out how to do screen printing myself ... we didn't do it at school. I used acrylic paint and paper stencils. It was the effort to get a sense of self and what one does and I saw myself in the role of an artist or somehow saw it as differentiated from other roles. It gave me sense of identity. I spent hours and hours making very technical drawings of machinery, ships and trains and quite complicated things imagining that I was a draughtsman.
>
> At home I continued to work. I knew from the time I was ten that I was going to pursue art as a career. I received full support from my parents and my art teacher. The art teacher used to say there are two kinds of people: those who allow things to happen to them and those who make things happen. I knew that I definitely wanted to be part of the latter.
>
> I was always drawing. I used to do lots of illustrations. I remember drawing dinosaurs and taking them to my school and everyone saying -They're fantastic! All of my desires were related to art making.
>
> My art teacher set quite a few projects which I spent a lot of time pursuing at home as well as at school. I was visiting an aunt and uncle and in a cupboard I found a box of paints - oil paints. I took them home and attempted to teach myself how to use the oil paints. It was a matter of trial and error.
>
> We used gouache and watercolour. I made my own clothes and even attempted to make my own shoes. I would try anything I tried to carve some clogs like the Dutch wear. This was when I was nine or ten.

> I remember very early on saying that I was going to be an artist, or an architect or a draughtsman. I was going to draw! That's what I was going to do - something that involved drawing. I had no idea what it meant but always I was going to draw. At home I made a lot of art which was very separate to the school art. I was interested in drawing and I ended up years later majoring in life drawing. I was one of only two people who majored in drawing.

Ten of the subjects commented on the fact that they often experimented with new media. Often they were denied the right to use particular art media at school because they were not considered old enough to successfully use the media. A particular example of this was oil paints. Consequently, eight of the subjects remembered spending time experimenting with oil paints at home. Some examples of such experimenting are:

> At home I bought some oil paints and tried working with them. This was my first attempt at oil painting. I can remember trying to do something similar to a Degas - with his ballet dancers - trying to get that same sort of technique.

> I remember when I had the oil paint, I was sent to the shed to paint with them because I think my mother knew that I would make a hell of a lot of mess with them. But you know I had. Yes, you see I did have ideas of how the oil paint could look. But that might have even been off the tin. Just a tremendous frustration of not being able to make the paint conform to my idea of what I thought it ought to look like.

> And I can remember so clearly discoveries like working out how to make fence posts stand vertical when I was drawing the mountains out of the classroom window. I can remember drawing them and realising that they were lying down and figuring out how to make them stand up.

> I can remember looking at the mountain range and actually trying to follow the contour of the mountain range whereas every other kid in the class was - if not ruling - drawing your triangles. Stuff like that. I suppose the sort of environment I was in and the opportunities I had were sort of practising and sort of gave me that sort of edge on the other kids. But we did very little art at school. Actually it was a reward on Friday afternoons.

> By then I had my own oil paints which I found very difficult to use at first and there was no tuition at school for oil paints. So some of the things I remember - the paint being absolutely unworkable on certain things and you know get a ball up on a piece of paper after a while because you were using turpentine or it absorbed into the paper and things like that. I didn't ever take those to school and say why isn't this working? I tried to work it through for myself. Skills were acquired by perseverance rather than by tuition. Most of the skills I have I have learnt on my own and it drove me to prove that I could paint the things realistically.

> A lot of the technical knowledge used in the drawing of the strips was by accident. Even when I look at the first graphic novel that I did, which was the first ... book. Mind you there's about three versions of the whole ... series. There's the one version

> which was the really rough old school comic version and then in about 1983 - 84 - 85 there was a version done in pencil. The problem with that was that it was all done in a book and it doesn't photocopy, you can't reproduce it. It sort of annoyed me so I went on and had to relearn everything using pure black pens. You can look at the first book which I did just using pure black pens which was about 1986. You can just see looking through how - you can see the style evolve throughout the book. About two thirds of the way through I learn how to use the hatching properly. The first part it is a little bit all over the place. It gets better as it goes along.
>
> In fourth year, I found that huge satisfaction in making good work for myself. This wasn't a class activity or anything else. For some reason, the class was dispersed and I found myself making a drawing of a very good friend, who just happened to have turned around to talk. It was a magical moment because I found that as the drawing developed we both became aware of how important this was becoming and the drawing probably took the best part of an hour and it was then that - I mean I was pleased with that drawing because it was a very good drawing for that age - and I think it was probably the realisation of that depth of feeling that you can get out of this thing called art making that happened then and that's why I did art at Matric. because there was a lot of pressure on me - being a fairly good academic student - to take other subjects rather than to pursue this frivolous activity called art.

Half of the male subjects met the disapproval of their fathers when it was clear that they were taking art-making seriously. The desire to become an artist was not considered to be a sensible way of earning one's living. It was not considered to be work or an appropriate occupation for a 'real man' to consider. However, despite the disapproval, the subjects persevered with their art making. An example of disapproval provided by a subject is as follows:

> At home, I remember my bedroom was filled up, began to be filled up with art work. I would start doing things on walls and I pinned things up and made designs and found old bits of cardboard and sat in my bedroom and painted - much to my father's absolute horror! It just became part of my life. It was getting to the point that, in some senses all I was living for was art. I would devour, I began to devour every book she'd [the teacher] give me. I would just take the books home and pore through them.

Eight of the subjects reported having held out against their parents' wishes in their determination to take art in the senior years of school. For example:

> There might have been a bit of stubbornness or perversity already showing itself because that was a reason behind pursuing this in that all the rest of the family then went on to do clever academic things at University. I do know that I wanted to do something different. But then again I think that is an aspect of the artist he or she feels the need to assert himself/herself against the bulk - push out in some way.

I did a lot of drawing at home. I did my first mural when I was about ten or eleven. I had a playhouse and I painted the ceiling of my playhouse. I used my hands to print on the ceiling. I always wanted to be an artist. I always wanted to make art. I always spent so much time painting and drawing and making things. I know very clearly that I argued with my parents about going to the Academy rather than to interior design. Interior design was the closest to what I wanted to do. I went to the Academy and enrolled myself. My parents didn't know about it. I just said that I wanted to do it. On Sunday mornings I used to go and do painting and I think it was three or four evenings a week I did sculpture, but that was only because they didn't have painting at night.

I loved horses. And I taught myself to draw a horse's skeleton with every bone in it. So I got quite a good horse but it was the most ridiculous way of doing it, I mean I can still draw a horse. I don't want to draw the horse's skeleton. It was a horse on sideways and it was always facing the same way. Well it is always hard down at the bottom of the legs there, so what did you do about that? I did horses in motion as well, I did horses going over jumps and rearing horses. And I can once remember, there is a very old house across the road from my place which is now where the Catholic priests ... live and it used to be owned by some people called ... who were great horsy people. Once they have had an old horse with a foal there and I did a painting, I don't know where I got the paints from of this little foal drinking milk from its mother and I can remember getting a great deal of praise for that and I think the mother kept it. That was almost a painting from life that I did, something that I, I will say in words, must be art work as I did as a child whilst imaginary.

Drawing was my thing and I followed it right through academically, but the figure was the big subject for me and I think as an adolescent it was sexual as much as anything else you know - voluptuous figures and all the rest of it.

I made lots and lots of drawings of naked women and being very embarrassed because my cousin or some body found one of these drawings and I was embarrassed. One I had screwed up and thrown away and she had found it and took off and I chased her around the house trying to get the drawing from her. At home, drawing was something that I always did.

The drawing on the verandah was very intense and went on over a long time. I drew trains The buses with all the people hanging out. The hospital ships with the big red crosses on them were a favourite subject too. I remember once making the bottom of a ship, I was quite ingenious folding up the bottom to the side and I realised I hadn't drawn the two fronts exactly the same, they weren't matching so I had to redraw that , I did it all freehand.

Nine of the subjects mentioned that they had often spent time in class drawing on the covers and margins of their exercise books when they should have been paying attention to their teacher or working on tasks for that particular subject. An example of this activity is:

I used to draw faces everywhere and on the inside of my books at school, I used to get into trouble like that. I used to make lots of little drawings in the margins and I

can remember once the teacher was really cross - she should have realised that we needed art lessons and she said, 'What do you think you're doing?' and I said, 'oh! I was just thinking.' I was thinking visually.

Group 2. Familial influences

Category c : Parents and grandparents.

This category refers to the support and encouragement provided by parents and grandparents. Thirty three of the thirty four subjects made at least one reference to the fact that they had received encouragement and support of some kind from their parents and/or their grandparents. In all instances, the subject was immersed in art by at least one parent.

My father was a sign writer and a painter. He filled the passage and the bedrooms and his shed and various other places with these images from television which we'd been looking at for only two or three years.

Both my parents were artists. My dad started painting first. My mum - basically she'd been employed as a young woman painting greeting cards in London, just before the war and dad launched into it basically as a hobby thing, but mum, being a professional artist took it on and went with it. With dad it was always a hobby. My mother became quite a well known professional landscape painter in Tasmania.

My parents were interested in landscape painting .... My mother was taught at art school ... her work was fairly loose and painterly. My father was taught by Godfrey Rivers and his work was sort of fine and meticulous. I did see my mother at work making art.

My father used enamel paints and he used his sign-writing brushes and sign-writing materials and painted Goofy, Donald Duck,. And they were big. They had a real presence. Sometimes he'd borrow images from *Pix* and *Post* magazines of *Saltbush Bill* and in some cases they'd be pictures of rugged desperate farming people with cows being milked in humorous situations.

I persisted because I was supported by my father. My father gave me positive feedback. It was recognised as something I could do well.
My parents were positive in supporting us in any thing we chose to do. They said to just think about it, and think about why and make your decision and stand by it.

I just made things. My parents had a sailing ship in a glass case. I was allowed to take it apart because it had been left out in the weather and had broken down and I remember taking the pieces out and finding all the wooden sails which were shaped like square rigger sails. I played with those and put them together and that was the first thing I can ever remember of actually holding something in my hand and feeling

that it had shape but it wasn't a cup or a saucer or bowl or something like that. I was about six at this stage.

Another big influence from my father was woodwork. He always had a work shop and we were allowed to go in there but we weren't to touch anything. I can remember just standing there for hours. with my hands behind my back , watching at how he did this. Then it was very easy for me later on to make things. He made some of the furniture in the house and was quite good at it but during the war he was mending other people's cars as well. He was into mechanics as well as woodwork. He could handle all the equipment. It was the hands-on thing that I think was a strong influence. His paintings were around the house. There were six or eight of them in the living room and in his study, nobody else's paintings though. There weren't reproductions. In other people's houses there were reproductions, but in our house there were real pictures. My mother was aware that I was interested in art. I suppose she must have been as she always had it mapped out what we were going to be because she was a very dominant person in the family. I was going to be a kindergarten teacher because she knew you had an art training for that, and so she'd sort of mapped that out. My sister was going to be a jeweller because she liked fiddling around with little things. It is interesting that she has ended up sort of doing that in her later life. The big thing that I see in retrospect now was that you weren't an artist until you learned how to do it properly. That attitude went right through until I was sixteen and then because I was interested they didn't really like that because I was too serious about it. It was OK to be a teacher and go and make art on the side but I think my father was aware of the emotional dangers - the tight rope sort of thing and my mother just thought it was terrible because they were all Bohemians. So from both sides I kind of got discouraged. They wanted to discourage me .... It was the art in the family that first got me interested obviously, but it was very much the life style as well as the interests of my father in architecture and he sort of restored every rectory he went into, and I'm still wanting to restore houses. Those sort of things seem fairly minor, but in a way they are important.

My father always made things, he was a woodworker and an electrician he made all the cupboards in the house and he made tables and chairs and everything so that sort of workshop mentality was really nice to be in. He was making things all the time, so there was no or very little visual stimulus. There was always the radio. We didn't have TV until I was twelve.

We had few books and comics were not encouraged. I do remember when I was about ten doing lots and lots of cartoon drawings of Tom and Jerry and Mickey Mouse and learning how to draw Mickey Mouse easily like in five easy steps. My father taught me that. My father used to like drawing, so we used to - there was an Indian Chief one too - another one of dad's easy to draw while he was talking about things. They were just simple symbols that were easy to draw. My father was probably a frustrated artist in many ways he was an amazing draughtsman, I think his expectations were probably that I should do something like he did, and he was much better than me and he was also much older but he forgot those sort of things. He had certain expectations. I remember my mother saying to me when I was much older that she'd said to dad at one stage : You know ... is only so old - why do you expect her to do what you're doing? Maybe that's another reason why I actually - it was something private for me. That way I could set my own pace and I didn't have to live up to his expectations.

I was aware of the fact that my father fancied himself as being a bit of an artist ... we had a garden shed turned into an art gallery - that was my father's initiative

> because he was interested in art and liked to encourage us ... When I was in high school he was very encouraging of art and he actually paid for me to have private art lessons including drawing from the nude ... it was interesting that he encouraged me even in that respect.
>
> There were influences other than art on what I am doing and those influences have come from my parents and extended family and other people in the community but often those people were not involved in art but they were involved in some other activity.

A third of the subjects had been provided with technical assistance as well as help with the execution of their imagery by a parent.

> We weren't taught anything during the pastel drawing periods at primary school. Teaching was at home with my mum. My mother taught me all I knew about using pastels. I was never able to relate those processes to school. I never excelled in art at school.
>
> I had to illustrate a project about the apple industry in Tasmania and I can remember drawing boxes on a wharf and they looked peculiar with their funny little lines going in all directions and dad showed me about perspective then. I'm sure he showed me how to draw boxes on a wharf - lines going to a vanishing point. It just sort of clicked - I was ready for it at that time and consequently I could sit in front of a thing and draw it after that as far as getting it looking reasonably right.

Some subjects were fortunate enough to have parents who, while they were not knowledgeable about art, provided opportunities for their children to be involved in art-making activities.

> Before I attended school, I had a lot of support from my mum and dad in my art making. Although none of them were art makers they did make little drawings for me. They produced little examples of animals like pigs and ducks and birds, which I could copy.
>
> My father did drawings. He was an engineer and did a lot of engineering-type drawings but he was also very good at quick sketches, caricatures of us, or cartoon sort of things he did. And I used to think he was pretty good because, it is rare to find a person who can actually draw something and who does it for pleasure. And in the attic of our house, sometime before the war when he was quite young he had bought a set of oil paints and several books to do with how to paint landscapes. And this paint box was in the attic, it was large and black with all little compartments and had little bottles and jars and very ancient tubes of oil paint. That I suppose made me aware that people actually painted ... my parents encouraged me to do drawings.

> My parents and friends of the family realised that I was keen on drawing, so every Christmas and every birthday I was given books about art ... all the influences came from my immediate family ... my mother has always been my greatest fan .... My parents and my art teachers at secondary school were all very supportive and encouraging to me in my development as an artist. My parents were very keen for me to do what I wanted to do and have always been supportive.

The provision of basic materials such as paper, paints and pencils was a common way in which parents provided support for their children who were immersed in art-making.

> We were given chalk to draw with [by my parents] and we would spend a lot of the day there drawing on the verandah .... My father gave me the paper ... it was thin paper and I used the tab and slot technique to hold the structures together.
>
> We had lots of paper so we'd just do one drawing after another. My sister and I both used to draw. Those memories are still very strong-sitting and drawing. We were very lucky too and Dad used to bring all sizes of pads so we had big ones and we had little ones where we would do little, quick drawings.
>
> Early on, I think it was at primary school, my parents gave me a box of water colour paints. They were aware that I enjoyed art and as and when they could afford it they provided me with art materials.
>
> My father worked at the government printers, so we always had access to pads of paper, and he always - holiday time used to be the time when he would bring home some pads. We used to go to Oppossum Bay for our holidays always in the winter time. It was lovely. Mum used to take us and we'd have these big roaring fires and we'd sit up in the morning and we'd draw and draw.
>
> I was brought up in a fairly creative sort of family. I had a grandmother who painted, wrote poetry and did a lot of drawings on an amateur basis. My mother was creative too in a strange sort of way - she did a lot of drawings, she read a lot and wrote poetry. Poetry was the aspect that was right through the family. I was always encouraged to make drawings of some sort. If I was with my grandmother she'd give me paper and stuff or if I was with my mother she'd always be giving me pencil and paper.

A third of the subjects were encouraged by a grandparent who was involved in art making.

> My grandmother was quite a skilled painter and draughtsperson. She had been to Art school before the turn of the century, but hadn't, I guess, done anything after she married. She had some paintings by a cousin and a friend, so she must have been part of that group, but I'd never seen her sketch books, or anything like that. Anyway , she drew me a witch to take to school and it was a good witch. My teacher went bananas over it! I had a grandmother who was an artist. Instantly I became an artist then too! It was absolutely inevitable: that was about Grade 3.

Although nobody said to me - you're an artist, I became an artist in the eyes of the world in Grade 3.

There are some people in my family like my grandmothers, who I considered to be artists - they were considered so by my family, so there was an interest in painting and in making things. I reckon I had quite a lot of opportunities to make art - a lot of materials with which to play - a lot of water colours and paints, wax, crayons and just the usual sorts of things that little children play with.

My grandfather was a visual artist ... this was in Hong Kong so he was a Chinese visual artist ... what I remember is of an old man wearing glasses bending over a large table made of boards putting black lines in brush and ink onto paper with great dexterity and making beautiful pictures ... In terms of art I would say that my grandfather was a very pivotal influence .

Category d: The environment

Thirty two of the thirty four subjects referred to some aspect of their childhood family environment as being significant to their development as artists. The natural environment was identified as a particular influence. Fifteen subjects referred to the natural environment which was part of their regular home surroundings. Examples of subject responses regarding natural settings in their family environment are as follows:

We looked over the sea and I drew headlands and whales, must have been whales and stuff we saw and you know. In Sydney on the northern beaches ... it was developing urban. It had been a holiday village. And it was just at the stage of booming as a residential area.

As a small child I can recall having an affinity with nature - trees, the sea, beaches that sort of thing. I really loved that environment. It was a huge family home more or less in the country. I grew up in ... in my very early years I was born there. I loved that environment too. The bluff and the beaches and the causeway and the Norfolk Island pines.

It was the idea of the sea and ships - I had an attachment to - because I grew up by the sea. I was obsessed by it. I would have been a sailor if I'd had courage or something.

I made mud pies before I went to school. I can remember drawing on a wall at home. We were brought up in the Dr. Spock era when you were allowed to do almost anything- we weren't told 'no' very often. We basically wrecked our house. We moved a couple of times because we made such a mess of our houses. We were basically encouraged to think that we could do what ever we wanted within reason. We were always reasoned with and so I think that there was an expectation that we

should be creative. Anything was possible. We had quite a lot of paintings and things around the house. I have a very strong formative memory of a painting from my great aunt's place - which I now have - a watercolour and I'm convinced it has had an impact on every thing I've ever done since. I can remember when my aunt died, she was in the big, old, family house, and they'd been there a long time - she died and my father and his brothers were organising the estate and there was a debate about who would get what. They got together over a whisky around the family dining table and I remember begging dad to get the paintings and prints and particularly this painting which has always been mine ever since. The interesting thing about that is, that I'm sure it was when I was at primary school, falling in love with a water colour in a gallery in ... there are a lot of Antique shops in ... Road - and there was a fabulous watercolour - I'm convinced it was by the same person - and I begged Dad to invest in this painting. I can remember the impact of this painting.

We mainly played outside, we mainly manipulated mud, we made art out of the mud as kids and probably we made sort of in that sort of constructive play where you make things that was probably more things like moats and boats and rafts and billy carts and stuff like that. So we were, even in a very wet winter we were always outside. Had your gummies and your raincoat and you just, that is what we did and we played in the shed and we made things in the shed and so on. We played animal games. We were a family of squirrels which must have been influenced by I suppose by the sort of story books we had. There was some fantastic settings for play as you can imagine. Well, having gone back to that farm just last summer holidays to have a look, it is an incredibly featureless place and it is very hard to sort of square that with that very alive sort of memory of incredibly sort of detailed and rich, very rich environment for play, swamps and man ferns, huge trees and lovely bush going right down to the river.

My parents had a shack at Cremorne and we always drew on the beach and made things out of sand so I suppose that was art. When I was quite young we moved to a very old house. My grandmother lived in a big old colonial house which has got a wonderful garden and acres and acres of land. And we moved in to the Gatekeeper's Cottage which originally was quite tiny but had been built on in the early part of the century so it was quite a big old two storeyed house. And that's where I spent all my childhood.

A solitary childhood, running wild in the bush and on the beach you learn so much and you learn more than just the physical reproduction systems of insects and how grass grows and all those things you understand that there is a definite connection between all of those things and yourself.

I can remember my third birthday - going out in the morning very early when it was all fresh and dark green and the shadows were dark the grass was long and it had dew on it - I remember those things - and I remember plants and colours. I was astounded by the beauty of the landscape when I went to Austria - I remember walking 5 miles on my own to get sweets but I walked back and it was a fine afternoon, windy and I sang the whole way - it was like a psalm just praising nature or God - it was a - I felt that I belonged. I remember a landscape as a place to be a place that was created.

I grew up in a country town .... I just remember a couple of places. I remember the first home I lived in was kind of big and rambling and lots of play stuff like - being the youngest child it was a lot of fantasy stuff I indulged in like playing, I mean all the stuff I guess kids do - Cowboys and Indians and all that kind of thing. ... then

> moving to a new house in a different place but in the same town, a much more ordered and probably newer place. I kind of remember spending a lot of time outside.
>
> All the things that made an impression on me were things like home stones which are these standing stones in fields with pre-Christian marks on them .... Just places in the landscape that were significant or ... even in Ireland, certain types of bushes are ... I was in the Cub Scouts and we used to go away a lot on camps and the whole structure of the organisation was based around Irish mythology so the kids were divided into groups named after people in the myths...
>
> Halloween is an Irish festival and dressing up as kids, going around the streets knocking on people's houses. There is Stephen's Day - you call it Boxing Day there were people called the Straw Boys who would dress up and they would put coloured cloth on trees and it was like Halloween. The main influences on me as a potential artist the nurturing and development of my imagination and the role that had in life at the time and its importance, so that might be religious, it might be a mythological sense or it might be an artistic sense, but this is what I come back to about the fact that people had these activities and just a world of fantasy.
>
> The environment was lovely. I can still see it all. There was a small central street and one pub, one church, little thatched houses, we were near an army garrison which meant that there was a bit of movement. We lived in a thatched cottage until they condemned it and pulled it down. You went in the back door and there was a beautiful stone floor and there was a tiny little sitting room rather low and dark. I can remember the garden where I made the mud pies next to the black currant bush. The fields around all had names. The trees were all identified too. We were very much part of the land.

In other instances, subjects experienced the natural environment during holidays with relatives or on camping trips with parents. Examples of these responses are as follows:

> My great aunt and uncle had a farm in the country. I would spend time with them in holidays. It was quite rugged country so it was sort of frightening as well. There were pictures of farmers as young people still with their army uniforms on with their ploughs as though they had just got the land under control in a way and the whole thing had a sort of difficult air to it. We went there a lot. My father went hunting and fishing.
>
> A strong influence on me was that every weekend we would go out bush walking. Mum and dad and the two others until I was fifteen or so and then I got to the point of saying: No, I am bored to death with this, I don't want to do it any more. But I realised only a couple of years ago because I was always quite interested in the fact that we had no religious training at all so I've had no religious influence (or so I thought) on me. I can remember going to church a couple of times. Then I did realise that that thing of going out into the bush on a Saturday or Sunday for as long as I can remember until I was about fifteen and my parents were just in love with the bush. My father works in the Botanic Gardens and so he had a fascination for every plant he came across and my mum had grown up on a farm and so she used to be able to tell us all the names of the birds we could hear and identify tracks on the

> ground and between them they were inspired about it. I just took it as normal and the older you get the more bored you get. It seems that it was the equivalent of a positive religious upbringing. It was funny recognising that so late . I think that was a much stronger influence on me than anything in the way of popular culture or even art directly. In school holidays we went camping and bush walking with my parents. We would travel all over Victoria, New South Wales and Southern Queensland. It was a fairly close family unit and I guess they must have gone during the summer holiday and one of the other term holidays camping and the other one we would have spent time at our cousins' place. My aunt was an amateur theatre actress, repertory and a very good singer. In some cases, school excursions were instrumental in exposing subjects to the natural environment.
>
> During my matriculation year we went to Wilson's Promontory and started drawing what was around us. It was part of a school camp. I drew seascapes and rocks and developed a series of oil paintings from them which became my matriculation folio or part of it.

In the primary school setting, Nature study was a curriculum area which provided some subjects with opportunities to study aspects of the natural environment. Following are two examples of these responses: ,

> We did nature study which was a very important part of the curriculum We went out into the environment and looked at the birds, animals and plants. We collected plants and pressed them and drew them.
>
> I loved our nature study lessons, they were wonderful. I remember dissecting a sweet pea and doing drawings and colouring them in very carefully with coloured pencils. I absolutely loved those lessons .... I did tend to excel at nature study, and it made me very proud because the other kids would say 'can you help me with this?' .... I guess in a way that might have been the beginning of my love of painting flowers although it was a long time ago.

Objects in the home such as original art works, reproductions of well-known art works as well as ornaments and craft pieces such as pottery were also significant for many of the subjects. Examples of these responses are as follows:

> My mother collected Chinese paintings and pottery. She wasn't a collector but she just liked nice things and Chinese paintings were very cheap, some of them were very old but most of them were very minimal brush drawings. My father liked painting too and there were Picasso prints around the house too. I found out about Rousseau from reproductions of his work at home. There was a Gauguin I remember but I always found it rather depressing. There was a van Gogh but it was terrifying. I found it almost forbidding as a child.
>
> That early background environment (There is a lineage of sign writers - my grandfather was a sign writer too) and my grand parents were fairly important to me and he was an arbitration court judge who travelled off to see the Coronation. He

was invited off to that so there were photographs of their ship and photographs of Austria from their travels around their house and I remember those.

It was a very supportive environment, lovely environment. And I think that is probably a strong memory from earlier on as well. Not to do with my art making but just the environment was the fact that mum was always sewing, constantly sewing. There was always material laid out on the table or there were always people coming around in the early evenings to have fittings for wedding ensembles, bridesmaids costumes. And mum was always sewing for the church, and they were coming around for fittings and things like that. There were constantly fabrics out on the table. And in being packed away as the evening meal was being prepared, it is a strong memory for me.

I would have been six or seven years old when I saw these prints along with Tiepolo, Van Gogh , Picasso, Kokoschka, Gauguin ... they were in our house as part of my father's collection. Then, when I was fourtenn, my brothers also got interested in painting and we had started collecting our own prints. By then, by the time I was fourteen, I started to like the work of Braque - I even bought prints - I used to be given pocket money and I never knew how to spend it so I bought a Ceri Richards print of a girl playing the piano and I had it in my study at school for a long time.

There were two huge portraits of my great-grandmother and great-grand father and they are still in the family and they were always on display ... they were so big that they used to dominate everything in the room, so I can remember them.

At home, there were pictures on the wall. There was one reproduction of a Rembrandt in the best room and the best room was not to be used - it was kept for best! But I suppose the only thing is that I didn't like the people in the picture and it may have been that dark tonal value that's in Rembrandt; but it might have been the expression on the faces. It was a group of men around a corpse. It was probably one of those anatomy lessons. While we didn't see the corpse we saw their faces and I don't think I liked them very much and there were a couple of Frans Hals - the Laughing Boy perhaps- but I didn't like them either. That was the sort of art work that we had - reproductions of known and respectable works.

In our house we had some oil paintings. We had a really big one actually - it was about two metres long I think. It's a huge scene of the flax country where I grew up and it sort of shows the old and the new way of manufacturing flax. My parents still have it as a prized possession.

At home we had some old oil paintings. One was of my great, great grand father, and I can always remember looking at it and thinking: Gee, that's clever, I wonder how you paint so finely. How do you do that ? It's the same sort of experience as going to the gallery. I can remember thinking: how on earth do they make bronzes? I used to think that they must have carved it and I could never work out how it happened.

There was a lot of decorative art in the house like porcelain sort of cherubic figures. There was always a lot of stuff around, particularly at my grandmother's house. She used to do courses. She'd be doing this ink scraper board technique - she used to write a lot of poetry, which she used to read to us and she illustrated it. Itwas mainly for the kids most probably - but for herself as well.

I remember the lustre ware pottery that was displayed around our house. I thought it was absolutely beautiful ... and I was very interested in those Chinese moulded junks and things like that with little figures stuck around the outside with little scenes. I think most of my influences were from my home environment. I think from my earliest memories I was always fascinated with seeing things-you know more visual things.

In a funny sort of way, although it was a conflict, I still think that the home environment was so important because my father was a clergyman and he didn't have a job, like any other man had a job, he decided when he went and visited people and he spent most of his time in the workshop so in a funny sort of way it was a kind of - it was the artist's life - like there wasn't a job and yet there was a job. Later on when I decided I wanted to be an artist I just decided well that's what I am going to do you know - I'm just going to have a job that allows me to do what I really want to do and I have always sort of continued and teaching has always enabled me to do the other thing.

But all the aunts were people that seemed to be making art. It was traditional for people because I gather that they were the ... and the ... were quite well known down the N. W. Coast and it was the practice that the ladies of the house - and they were obviously refined ladies- did things like needle work, like water colours and so on. They wrote poetry and read books. The house had a beautiful smell about it. Whenever I went to visit them - there was just something unique about going there. I always loved to go there because there was always something to see, to touch, to read - it might have been a beautifully bound book or it might have been a picture they had just finished painting, but there was always something to see. There were lots of things in the home that affected me and it tells me how your values change or how your position changes. What I thought was absolutely magic doesn't appeal to me any more. As a child - to go into my grandmother - my mother's mother who was living with us - above the open fire place she had what I thought was a magnificent overmantel with pictures down either side. And it was the traditional picture that fascinated me as a child - here's this wonderful sunset with a tree and a deer and a stag coming up out of the water and I used to sit there and look at think - I wish I could do that. The other things that interested me were to look at all the old photographs. It was traditional to have those ornate frames and the family photographs. The wife sitting and the husband standing behind and I used to love to look at all those . The other thing that around about that time of early school, I got to look at Dad's books that he had when he was a kid ... the *Our Boys* Annuals and things and I was fascinated by they way in which those illustrations and characterisations of people in there were done - the line drawings and so forth.

The other thing that I particularly remember were some wonderful drawings that my uncle had done. He'd done these quite large pastel drawings on pastel paper - things like sunsets - and there was one of a bride in her wedding frock and I thought that they were absolutely magic how well they were done. I don't know how many drawings - maybe there were only six or twelve drawings I don't remember, but I do remember their magic. That would have been before school or early school influence. We had two tin plates in the hallway with a picture of Constable's boy drinking from the pond, and *The Haywain*. They used to make wonderful targets for those guns we used to make with the rubber bands. I used to fire at the tin plates because I knew when I had hit them because they'd go bang. We had large, Romantic pictures framed with moulded gold 3x2 they hung above the fire places. One was of a girl clutching a cross with her eyes turned up to heaven and the other which my sister

> still has in her shack ... of two small children crossing a bridge. They were coloured prints. We didn't have any original art work around at all.

Having a personal work space in the family home was a significant support for a third of the subjects. Sometimes this situation was made possible because the parents wished to support their child while in other cases where a subject was an only child, the individuals were able to create their own personal environment. An example of a response concerning a personal work space is as follows:

> By about the end of high school, I was given the big room upstairs at home. I kalsomined it out a nasty turquoise colour and I had put into an old frame, a Sali Herman bluish house print. I must have been given the room so that I had space to do things. I had my box of poster colours on a table up there. I did a lot of drawings and they were things that the family liked too because they were fairly sharp drawings of people like the old ladies who used to visit us and fat people at bus stops and the family used to like them. I used to send the odd pen and ink drawing to *Woman's Mirror* and they'd get published sometimes and my family used to think that was pretty good. Dad used to. He was quite pleased about that. But I thought the real stuff was at school.

Category e : A significant other

This category refers to other adults including members of the extended family, a family friend, a neighbour or even a chance meeting with an artist who provided support, encouragement or motivation for the making of art.

Twenty eight of the thirty four subjects referred to the impact of a significant other on the development of their interest and involvement in art.

Family friends who made art were often very significant. It is important to point out that only in rare instances did the subjects ever see an adult artist actually engaged in the act of art making. In some instances, they saw the studio or work space but in the majority of cases, the knowledge of the art making was entirely based on the art works themselves. Examples of responses regarding the impact of a significant adult are as follows:

There was a friend of my father's who was a returned serviceman . He was a prisoner of war in Changhi. He was very thin. He painted and he gave me some of his oil paint tubes which was about the time I was reading the book about Dobell when I was fifteen or sixteen.

My best friend's father was an interior decorator and he had this wonderful way of blending one colour starting at the base of the wall and blending up through the wall. He used to do it with a brush. I was very impressed when I saw what he had done. To this day I value this blending - it's one of the secrets of art I think - blending without any apparent change. I used it in a painting I did recently, but I used a roller.

There was a friend of my mother's, who used to visit the house on a regular basis, I can't remember her name, I can't remember what sort of relationship she was to mum. But at a very early age I remember her making me some plasticine battle ships which I thought was the most wonderful thing in the world and I used to drive her crazy, the whole time she was there having tea and chatting to mum. I used to be working on her to make me these battleships. I remember them being such a focus for me .... And I was fascinated watching her actually constructing them and cutting out the plasticine.

My father had a friend whose wife was an artist. I was very impressed with her work and she showed me how to draw people using the correct proportions. I was very excited about that. I actually saw her at work. I visited her studio.

I visited a studio of a school friend's mother. I visited and played with her and just by chance we walked through her mother's studio and I was quite stunned. The style of the objects was Pop Art - empty tins and cardboard boxes.

My parents were good friends with a painter called Noel Counihan and a sculptor from Melbourne and they had quite a few paintings and drawings by Noel Counihan and a lot of other bits and pieces - prints and paintings so that has been there for as long as I can remember and I assumed from that that they probably moved in a little bit of a circle of some local artists and some visiting ones.

... was the first artist whose paintings (aside from my mother's) actually stuck in my mind, because it was different to my mum's work and I was beginning to understand abstract through her work, because she had that abstraction extension on her objective art. She was a good friend of both my mother and father. I learnt a fair bit from her work. The next stage on in high school I started remembering more but she was certainly the first. I can remember her standing in front of a painting and talking to my parents.

I had an aunt who did painting and we've got some of her paintings in the house - we've got paintings from a couple of aunts and an uncle who did arty things. One made violins and one made little landscape paintings. It used to be said that art was in the family.

I had a relative, my mother's uncle who painted, Uncle Jim, but I don't think I ever saw him painting. I saw some of the paintings that he did which were in some of the family houses.

... was an influence. He did some huge watercolours. And I know that he did them purely to get money. He had done the huge watercolours quickly and I thought that they were absolutely exquisite. I had never seen anything quite so stunning and I spoke to him about it. I can remember that he had a kangaroo fur jacket on and he said that he was hoping that they'd sell because he needed to reimburse himself for the jacket. ... came to the coast then and I liked his style. It was like the beginning of - they were subjective landscapes.

The most impressive person in my early life was my godmother who was quite a distinguished water colourist, painting birds and flowers in the 1940s. After years of not seeing her I've just made contact with her again and I'm getting ready to write some articles about her. She was the wife of a surgeon so she had no financial reason for painting - she just loved it and she's been working for the last forty- fifty years building up a wonderful body of work. They are influenced, I now realise by Japan because of the lovely space and design and lots of white paper and she has turned out to be a kindred spirit all these years later. I remember going to her place and her working on paintings of birds using specimens from the museum and also attracting honey eaters to her window and lots of paintings of flowers like fuschias and roses.

I would go up to their house and watch them at work. They both kind of took this great interest in me and looked after me. And I would watch him working in painting and he was mainly a painter. So that was my first kind of experience observing an artist, I mean it was a whole range of information, with it came a whole range of stuff, like the way you dressed and all those kind of things. So it was very liberating for me. But he was the first person I saw actually painting and it was on things like fixing up a house so he was painting things like tables and stuff. Painting them with figures and decoration and things, so it was quite interesting. And they would print all their own curtains and things.

Seven of the subjects stated that they had known a neighbour who was identified as an artist. Often they were individuals who lived in the same street as the subject.

A couple of doors up the road, ... used to live there and he was a watercolourist at that time. There used to be talk about him you know - J ... he's a water colourist. The latest Launceston Art Society show would be discussed. There was always a bit of an aura about him as being a painter.

... used to live across the road and I used to play with Robert, his son. I was aware that he was a painter. I would walk into the ... house and be playing and his father would be painting so I didn't think that he was unusual either. I didn't anyway because it was happening at home and there was ... up the road.

I met an artist who lived next door to us while I was at primary school. I was able to go into his studio. I watched him draw and paint. He was a commercial artist and he was one of the prime influences on my making a decision to become an artist.

I can remember that we lived next door to a painter. A lady who painted. And I actually went next door and painted with her a couple of times.

One of the subjects had art lessons provided by a family friend who was a practising artist.

> We used to have an art lesson now and then at home. My mother had a close friend who was a painter who is now eighty six and still painting and is well known - and celebrated. At that time obviously she was much younger. We would spread newspapers on the table in the dining room when she used to come and she'd give us a class - this would have been about 1945 - I have known this woman and I have remained friends ever since. The relationship is like the master/pupil in that she drew beautiful pastel drawings - very economical hillsides and rocks in Wales just the way Constable drew - just no fuss and no stylisation just observation and light - wonderful drawings. She was doing art classes in Cambridge when I was beginning there. I would just spend the day drawing. I would copy her drawings. I still have the sketch book of the copies I made and I think in the pastel work I do especially if you see her work it would be evident that there is something in the freedom and the variety in the way she uses marks in drawing which informs the way I use the mark in pastel. To me there is no doubt that the connection was made then.

At least two of the subjects mentioned an encounter with a total stranger who was involved in art making. In both instances, the subject had come upon the adult at work in the environment. The impact of the experience of actually seeing an adult involved in making art was very impressive. The experience was so impressive for one of the subjects that she decided there and then that she would become an artist

> At about age ten I was staying at St. Helens and a lady was painting at the wharf and I suddenly became very interested in art - it was the first time that I had ever seen anyone painting. It just happened by chance. I didn't know her. She lives in Hobart now. I just happened to be there and she was painting and I just immediately felt that that was something I'd like to do.

> ... came through as well and he took us for a drawing lesson and that was incredible because I drew a jug, I remember. These people just came out of the blue and it was wonderful. ... showed us some original oil paintings of his and I can remember some cows - it must have been his pre-abstract period and I think a flower barrow and his funny looking boyish looking wife. My sister and I kept wondering whether she was a boy or a girl and we thought she must be a girl because she had lipstick on! He had painted her a number of times. He showed us the paintings. I was very impressed with his work. I loved looking at them. They weren't very big but the paint was lovely and juicy. That was a highlight of my youth.

Eight of the subjects mentioned instances of observing the work of relatives other than parents and grandparents. In some instances the relationship was through marriage while in other instances the relation may have been an aunt, an uncle or a cousin.

> I definitely remember seeing all the tiles laid out for the mural. I can remember being very curious about [my uncle's] process of making those figures sort of semi-abstract. And being shown the relationship between the ... and the design of the logo, the shape that he made and being very curious about why he used all women in them and why they were actually naked and all those sort of things. But I don't think I had the courage to ask him why, I just remember thinking: 'Oh, I wonder why he does that? I wonder why he is doing that?' but I don't remember asking him why.
>
> My mother's youngest brother is an architect and he actually encouraged me I think when I was young, because he was old enough to have bought the first piece of land that he had when I was old enough to appreciate feeling like a person (about 11) and being involved with clearing the land and watching out for snakes and all that sort of stuff.
>
> I didn't actually see my aunt making art. And I didn't see George in the process either, apart from this sorting out of tiles into tonal values I guess that is what he was doing. I saw a very close connection between what I was doing and what they were doing. Oh yes I was making art! I was getting a lot of feedback.
>
> My aunties on my father's side were all particularly art people. They were all very old, very ancient and they lived in a house with lots of paintings and prints on the walls. They were single aunts and I was only a small boy, but I was fascinated by them. There was Aunt Priscilla and Aunt Lizzie. Aunt Priscilla was a poet and a painter. As a small child, I remember her reading me poems and I remember the rest of the family talking about her pictures. But all the aunts were people that seemed to be making art. They were obviously refined ladies who did things like needlework, water colours and small drawings. They wrote poetry and read books. The house had a beautiful smell about it. Whenever I went to visit them - there was just something unique about going there. I always loved to go there because there was always something to see, to touch, to read - it might have been a beautifully bound book or it might have been a picture they had just finished painting, but there was always something to see. Most of the paintings that I remember of Aunt Lizzie's, were of around Perth and the river. They were watercolours, and they used to fascinate me- that she was able to make these paintings .... I actually saw them in the process of making their art works. Because making in those days meant that people made a lot of things that they needed in the house, so they were always making something - a d'oiley, knitting, you couldn't help but be fascinated by their dexterity even as a small person. I sat mesmerised.
>
> I particularly remember were these wonderful drawings that my uncle had done. He was a Pentecostal pastor and he was living in Melbourne at the time I think. He'd done some quite large pastel drawings on pastel paper such as sunsets - and there was one of a bride in her wedding frock and I thought that they were absolutely magic how well they were done. I can scarcely pick up a pastel today without

thinking back to that folio. I don't know how many drawings - maybe there were only six or twelve drawings I don't remember, but I do remember their magic.

I was very impressed by my older brother's drawing ability and very - you know how children develop systems for drawing - and some where he got a system for drawing a head which has never left me and I virtually cloned his system up to primary school. I was very impressed with people like my brother drawing around me.

Category f : Religious imagery

This category refers to those subjects who were influenced by the imagery and atmosphere associated with their religion. One quarter of the subjects were raised in the Catholic Faith and indicated that the imagery which is such a significant part of their church and school life is something that they continue to work through as adult artists. Some examples of this influence are reported as follows:

The strongest memories of pictures on the walls I have is church-related imagery. Pictures of Jesus and Mary. I was from a Catholic family And with a fairly strong connection - we were altar boys when I was young. We went to local Catholic schools. And mum sort of worked for the church. So there were lots of images around the place, fairly typical sort of devotional imagery. I really liked those images and later on into school that was always a favourite of mine. The illustrations in the Catechism books were really gross illustrations too, but they were very powerful images.

In Belgium there is so much art work in the churches it is just like a gallery. I went to church every week. I went to a place - it was like a pilgrimage place - we used to go there and they had all the stations of the cross and they were sculpted in stone. I looked at them for the story at that stage rather than for the art work.

The works of art that were up around our school - a Catholic Primary school - the Good Shepherd, holy pictures, plaster statues - these were presented to us as art.

My religion has always been influential in my art. So yes, but you take it for granted that the church imagery made an impact. It wasn't until I went to secondary school that the Sacred Heart of Jesus became fairly important to me. As a primary school boy in a French convent school there were religious statues and there was a huge cathedral for the nuns at the back of the school. We had to go there for benediction and stuff like that. I was a devout altar boy and there was this very gruesome image of Christ rising up with a crucifix. The image of Christ had bruises and open wounds and it all really fascinated me. The Sacred Heart of Jesus always fascinated me. Christ was somebody who was obviously human with his heart on his garment. All red and palpitating and I always had a bit of a fascination with that image. The statues of St Joseph and the child Jesus, stuff like that, lots of religious iconography became obvious to me.

> I was much more confined to indoors at home. I made a lot of things from clay which was provided by my mother. I was making heads and angels. They were my attempts to cope with what was going on - they were religious themes. They were very important to me.
>
> There certainly was a strong sense of the intangible, of the spiritual, of mythology through Celtic and Irish mythology so you know, there was a very rich world for your imagination as a child and I know that was a part of school.
>
> I went to Mass every week until I was about fifteen. I've noticed at art schools very often some one says, 'Well, I'm a Catholic and dealing with this imagery or my imagery has got to do with the fact that way back I was a Catholic'. I've never heard any one say, 'I'm a Presbyterian I'm dealing with my imagery', or, 'I'm a Methodist'... many Catholics have a strong affinity with imagery and ... when I was a child Mass was in Latin .... I was an altar boy so I would have been around the smells ... it's not just a visual thing.

Some non-Catholic participants who attended Sunday School on a regular basis were influenced to some extent by the religious iconography of the Bible text cards which they were required to learn by heart each week. The texts were pasted into books for future reference. The illustrations on the small text cards were appealing because the finely drawn engravings provided realistic depictions of the images.

> ... we spent a lot of time at church - it helped develop a sensitivity, ideas of spirituality and mysticism and that sort of thing which to me is at the root of art. It's not just about learning skills. The process of projecting life .... We used to get little stamps at Sunday School - art nouveau-style pretty little stamps - I used to like them. I have a Christening certificate in the same style. These illustrations helped provide me with a sense of art.

Category g : Collections

This category refers to the collecting of sets of objects including scrapbooks, cards, shells, insects, rocks, stamps and toys. Thirteen of the thirty four participants made specific reference to the use of scrapbooks and sketchbooks during their school age years. Scrapbooks were initiated and encouraged by the parents of some of the participants. At school some had been encouraged to collect images and news items about current affairs for project work which had led to the beginning of more personal collections in the home environment.

> The type of art making that I can remember most was making scrap books. It was always on a rainy day and mum used to keep old magazines and things . We used to cut things out and make scrap books. We used home-made paste made from flour and water. I don't know what has happened to those scrap books but they were the things that I always remember making, and it was sort of made very much by choosing a picture and putting it where you wanted to on the page. Sometimes we did combination family things but quite often we just had our own page to do things with and I often think that influenced the way I put things together. Layering and collage and all those sorts of things.
>
> When I was around fourteen or fifteen, I had two collections going, one was about fashion, things that I fancied would look very nice on me - that sort of thing. The other was about art and I would collect everything that would come under my nose in the way of newspaper and magazine articles. I would cut them out and stick them in my scrap book.
>
> I still have a scrap book with the rabbits that I painted then. I painted a plate I remember with the white rabbit on it. I did some writing around the ears.
>
> Something else we did a lot of when I was young and that is cutting and pasting on scrap books. Just cutting things out from magazines and sticking them in.
>
> At home I was always making things; gluing, cutting, nailing. I used to enjoy cutting and constructing with paper. You could buy cheap coloured paper then and there were books you could buy that would show you how you could cut paper to make interesting patterns, figures and things like that. I always enjoyed making scrap books.

The idea of using a sketch book was usually prompted through studying the life and work of an adult artist or possibly seeing a documentary movie about an artist at work. At secondary school it has been a common experience to keep a folder of work at least for as long as a school year.

> I used to keep a little book of drawings and writing. I used to do a lot of drawings - small cartoon type sketches with captions. These were often done in classes such as maths and handed around in class. I was a great defacer of my exercise books. I'd be drawing and doodling the whole time in class. I still do it when I'm sitting around.
>
> I wanted to be a commercial artist. I did things like make story books and comic books and stuff like that. I made scrap books and I kept a sketch book too for my rough ideas. I did this at home but not at school. This was not at school.

One of the participants reported that her desire to make sketches was so strong that since there was very little paper in the house, she used the end-papers of her mother's books.

> I filled my mother's books with drawings. She only had a few books but I had read them all by the time I was ten. And you know the end papers - they were covered in drawings. I drew people, figures and faces.

Nine of the participants collected natural objects and items such as postage stamps or ephemera about film stars and pop singers.

> As a child I collected natural objects but only because it was an activity that one was encouraged to do and to put on display at the end of the school year. They weren't very important to me then, but they are now. Now I collect the objects because they are a further reference, an extension of the drawings and photographs or ideas expressed in words so it's an extension of the drawing or a deliberate ambiguity.
>
> I collected all kinds of things. I used to like sets or packets of things - accumulations ... bundles of mining samples in packets and bottles of things .... I collected all kinds of paper ephemera as well toy cars, trains and old cameras.
>
> The keeping of things made is very important. Keeping and showing ... it's the record, the evidence, it's why people keep paintings now and why people keep sculptures. That's why they keep sketch books - it's their library. A sketch book in fact is an artist's library.
>
> I used to collect wild flowers and press them. The school held competitions for pressed flowers and things. I went with a friend of mine all over the hills and we collected lots of wild flowers.
>
> I collected small stones and pieces of plant life and I would keep them in boxes. I imagined that some furry kinds of leaves were my little animals. They were real in my imagination.

Group 3. Access to imagery and ideas

Category h : Popular culture

This category includes comics, radio, television and movies. Twenty-one of the participants made specific reference to the influence of some form of popular culture. In some instances the images from popular culture were directly copied or at least used as starting points for the development of imagery in the

art work produced by the subjects. Seven subjects reported that popular imagery was a significant aspect of their home environment. For example:

> My father was a signwriter and a painter. He filled the passage and the bedrooms and his shed and various other places with these images from television which we'd been looking at for only two or three years. Television began in Melbourne in 1956. I think we went to my grandfather's 1957 -58 to look at his television so I suppose we were looking at *Disneyland* and cartoons. So that material would have been around. I can't remember when I would have first noticed it. My father used enamel paints and he used his sign writing brushes and sign-writing materials and painted Goofy, Donald Duck, and they were big. They had a real presence. Some times he'd borrow images from *Pix* and *Post* magazines of *Saltbush Bill* and in some cases they'd be pictures of rugged desperate farming people with cows being milked in humorous situations. That material was around the house.
>
> I have a slide that I inherited from my family: a scratched old slide from 1958 or 1959 and I'm in the bedroom with my sister. Behind me are these large, larger than life images of Disney characters, and they were in the house for quite a while.

Nine of the subjects made specific references to the influence of popular imagery from television programs. Three examples of the influence of television are as follows:

> Television appeared half way through primary school for me. It would have been - I guess I would have been about nine when we had our first TV. Prior to that it was Saturday nights at friends' houses. I mean they were exceptional. The thing at first. I just learnt to draw Fred Flintstone I think. He was an easy one or a popular one at the time.
>
> Television made a great impact. As a very visual person, television had a big impact; I remember particularly loving the *Mickey Mouse Club* which is all visual and lots of cartoons. I remember the cartoon festival at the movies when we went for the afternoon to the Metro at Malvern. I loved cartoons.
>
> I copied some images from the comics. I remember copying Fred Flintstone from television, various characters that other kids were interested in. I started copying, and doing drawings of them to give to them.

The imagery associated with popular music which was conveyed through publicity in popular show business magazines, long-play record album covers and posters were also very significant, particularly at secondary school. For example:

> I remember doing Jimmy Hendrix T-shirts. There was that famous poster of Jimmy with his Afro hair - and I did that on people's T shirts. As well I was doing T-shirts

> for kids of those horrible, horrible tacky images of cars with great big engines and huge mag wheels. I was copying them from comic books; I actually got orders from other children and I guess they were my first professional jobs doing Jimmy Hendrix on T-shirts for people. But it had started in primary school. Because I did a few just mucking around for kids and their older brothers saw them and wanted them.
>
> I remember a record player being in the art room. And there was always a pile of records around. And I think the visual imagery in the music was important to me. And that was probably very formative in terms of sort of the popular culture reference. And certainly what was coming through the television at that time was the music of the day and the imagery and the sense of style that was associated with the pop music world. I think it was when I was in year 12 I really liked Jethro Tull so there was this English extravagance that went with that. Big concerts and big suits, with bright fabrics. We used to go and see bands, if a band was touring through we would be going and seeing Jethro Tull performing live and sort of visually just thinking, it was just incredibly exciting. And Steppenwolf as well.
>
> I remember seeing the *Easy Rider* movie and the decorated motorbikes. I was very much influenced by that kind of popular imagery as much as anything else. But it wasn't something that connected through to maybe the art group at school. That was about drawing a pair of old boots on a table. Really getting a semblance of the form of the objects and about building a picture in a quiet sort of way and being helped by the art teacher to sort of get the space and forms to work. Our fine art activities were probably more influenced by commercial art than anything else when I was at high school rather than the other way round. Like the commercial artist had been, had all been schooled in Surrealism and then here we were as high school students, drawing off the commercial art and trying to do second hand versions of it again. It was a weird sort of a cycle of imagery that was going on. But no - pop culture wasn't discouraged at all.

For eight of the participants a significant influence from a popular radio program known as The Argonauts was Phideas, who presented a weekly segment which specialised on art making and art appreciation. The well known Australian artist Jeffrey Smart was Phideas at least for some period during the life of the program. Phideas described art works and told stories about the life and work of historically significant artists. Members of the Argonauts club were encouraged to send work to the radio station and in return, they were awarded certificates for their contributions. Phideas also provided regular feedback about some of the work he found to be particularly interesting. This feedback provided significant encouragement for seven of the participants.

I used to listen to The Argonauts on the radio. Phideas used to describe art works over the radio. I didn't ever send art work in for him though. I was more of a listener rather than a doer.

There was a man called Phideas- his Argonauts name. What I remember was the way he could enthuse his radio audience with his passion for visual art making and he gave it to me actually and I remember one day he described a work that had been sent in, because that's what children did - they sent works in to the Argonauts program - and he was describing his excitement that he had been sent a work that had been done on newspaper. The idea of painting on newspaper was quite horrific you see because it wasn't clean. But he was able to tell us how exciting it was and also another one around about the same time, he described how a child had done a picture of someone back on - and again this was strangely exciting and very, very different so I think it was the idea that those two ideas made an impact on me. I went and found some newspaper and dabbled away on the ironing table out the back. I did tend to do that sort of thing a fair bit in my upper primary years. I think I was largely excited by those ideas I heard coming out of the radio.

I used to sit and listen to the Argonauts. I was the only one in the family who listened to the Argonauts and the other members of the family didn't like it very much - the approach to me by the family was pretty much that I was a bit above myself. Mum used to always be trying to put me outside - you know - 'Go outside and play'. I had terrible trouble to stay inside to do the things that I wanted to do.

I listened to the radio when I was older. I would run home to listen. I can remember listening to The Argonauts and Phideas who spoke about art and artists.

I was an Argonaut. Actually they were my first real experiences doing my own art was through the Argonauts. I used to send it to them. I used to listen every afternoon. I'd come straight home from school and listen to that. By then I was doing my own things. I was painting. I was sending these other things away to Phideas and I had a stack of blue certificates. So I was starting to get feedback as to whether they were OK or not. I was getting approval from Phideas . I never showed the family much of what I was sending off. I'd put them in an envelope and pocket money was spent on stamps. This was during Grades 5 and 6.

Comic books were identified by fifteen of the participants as being a very important source of ideas and images for their art making. The imagery developed by Walt Disney studios was identified by nine of the subjects as being particularly significant. Examples of the influence of comics are as follows:

The only ones I copied were the Walt Disney characters - they were so easy. You had to remember to leave a white bit in the eyes. If you filled the eye in you couldn't make the characters look right.

I could draw Mickey Mouse and Donald Duck pretty good.. In the woodwork class at ... school asked if anyone could draw something on the doors of the wardrobe so me and my brother got the job. I did Mickey Mouse and he did Donald Duck . We painted them with enamels I suppose. They weren't very big drawings but a lot was made of them. I do remember toy influences from Walt Disney too, celluloid Plutos.

It was possible to buy reproductions of Walt Disney characters in celluloid. They didn't last very long if you sat on them. I was fascinated by them. Clarabelle Cow was particularly fascinating and so was the horse. I read other comics at high school level. These were more the adventure style comics with one illustration and the story. There was *The Wizard, Hot Spur, Rover,* and *Adventure,* I can remember some of the characters: there was Charger The Clutcher. *No Rest for the Wicked* was one story. There were the soccer heroes too. They used to have comics in them but there were mainly stories with a few illustrations. I also remember the *Classics Illustrated Comics.* They had very elaborate illustrations.

We had lots of comics. I used to think that the *Phantom* was wonderful. I used to have *Superman* and an English comic. We'd order it from the Newsagency. It was much sought after. A wonderful comic.

I read things like *Archie* and all the American ones but there was one which was called *Katie Keane* - and I used to love *Katie Keane* because I would cut out all the cut up dolls as a child, and dress them. But it wasn't before long that I started making my own dolls. The garments were always very sexy and revealing and much more daring and imaginative than Katie's dreadful fans ever designed for her. It is quite interesting, quite eerie how these things can come back to haunt you, like when I am designing garments now.

A lot of the things that I made in plasticine were quite intricate figurines. But plasticine doesn't last. They were characters sort of like Bugs Bunny but they weren't Bugs Bunny. I have always made my own characters all the time .... Television was probably more important than the museum. I was more interested in the animals then rather than art in a museum.

It was white clay. I made a little figure of Superman. It was about three inches high and I had one of those scalpel knives and when the clay dried I carved it and I even carved details like fingers and nostrils - very fine detail - I was very disappointed because somebody broke it on me - still I had a lot of pleasure in carving it. I think that would have been the only clay work that I did - or any three-dimensional work - in E or D class.

I loved comics. I collected them and I have all my original comics. I have always had a passion for them and I collected many different titles. The *Phantom* was always a special one, then later on when I became a teenager some comics came out that were very well drawn at the beginning and I avidly collected them but they gave me nightmares all the time so I ended up - and they got sicker and sicker - I couldn't read them. I used to collect them for the drawings but I couldn't be bothered with the stories. *Mad, Phantom, Batman* - often the best drawn comic of the lot - in some ways - I did copy some of them but I don't have much memory of it .

I loved comics and read them during my primary school years. I used to have the *Phantom, Superman, Ginger Meggs;* I loved *Ginger Meggs* comics. And I used to copy them, I used to draw all of the characters. I enlarged some of my favourite comic characters and put them on the wall of my bedroom.

I used to read comics avidly. I used to love The *Phantom* - people still do. I was a member of the Phantom Club and I had a ring that glowed in the dark. At one stage there was a whole lot of comic writers who were Australian. Apart from The *Champion* and things that I used to get from England: *Beano* and *The Eagle.* Monty Wedd and Emile Mercier were the Australians I can think of. I liked their drawings

> best of all and they were an influence. I always thought that Lee Faulk was one of my favourites. *Mandrake* I used to like and Brick Bradford - they were really quite visual.
>
> I grew up on a great diet of comics from my earliest years right through until I was fifteen or sixteen. I used to go into ... Bookshop. My dad was funny like that. He'd buy comics , gee he used to like comics. He used to buy a heap of comics every week. *Film Fun* and all those old things, you know. One of the earliest things I can recall doing as a work of art I'm sure it was Batman- I did a Batman lino cut. I remember I traced it - and I made that Batman lino cut. I was very keen on it. I carved it out. I just did that at home.

The images and characters portrayed in animated movies and cartoons were identified as significant influences. The movies of the Disney studios were particularly identified by one quarter of the subjects as being highly significant. Some examples of such an influence are as follows:

> I went and saw the Walt Disney animated *Snow White and the Seven Dwarfs* which was a big influence on me when I was very young. For a long time I wanted to be the Fairy Queen and my mother found some costume pieces for me - a cape, felt flowers in my hair and a wand. I remember the desire I had to be the Fairy Queen. It really influenced me. I liked the *Looney Tunes Cartoons* when I was at primary school. I loved the rawness of *Heckle and Jeckle* and *Mighty Mouse.* I loved *Dick Tracey* comics too. I tried to draw his profile.
>
> *Fantasia* was a wonderful movie. I remember a lot of the images, from Mickey Mouse as the Sorcerer's Apprentice to the Dance of the Hours with the Ostriches. They were the sort of images that I imagine most children of my generation would remember because they were the outstanding ones ... we lived opposite the cinema.
>
> You tend to be influenced by what is provided by your parents. I got interested in Disney- the thing that fascinated me I remember when I was in secondary school was *Fantasia.* It was absolutely fabulous. It was the first time I had seen something that was just simply abstract with colours and shapes moving around. It was magic. It made me wonder, how can a man think like this? How can someone create that sort of thing?
>
> *Fantasia* came along when I was a child. That affected me profoundly. I had nightmares about the Night on Bare Mountain all my life. The mountain has stayed with me all my life. The face of the devil has stayed with me all my life. I recently sold a painting to Apple Macintosh in Melbourne for their board room and I was shocked to see a tape of *Fantasia* the other day and realise that what I had done to their board room is the mountain and if they ever see *Fantasia* they'll recognise that that's the mountain. This particular mountain shape is all through my work and I'm sure that some of them come from *Fantasia* which profoundly affected my life - right from nightmares to my whole view of classical music and art.

More recently, the images from movies such as *Star Wars* have had a powerful effect on the image making of those subjects who were influenced by the popular cultural images. For example:

> While I was at primary school we had the *Star Wars* movie and for a kid of about seven, *Star Wars* was everything. It was a big influence on me. Most of the time in school, we worked through themes often to do with the seasons such as Christmas and Spring . Sometimes we had a free choice which was the time to do *Star Wars,* but mostly the art work related to popular culture was made at home.

The images from horror movies and the fascination with science fiction also provided ideas for the production of art. For example:

> But there were other things that my mother somehow didn't realise we were watching, like *Creature from the Black Lagoon,* stuff like that, horror movies and science fiction too. That sort of 20th century Gothic has remained with me as an influence in quite a way, I mean with my present day work .... I also remember seeing the 3-D version of *The House of Wax* And that I think is my first clear cut memory of bondage themes and sex. I can't remember how old I was but I was in primary school. I remember the scene where the woman was going to be turned into a wax model but she was strapped down into a little basin thing and the hot wax, it worried me a long time because she was entirely clothed and I thought, 'Well surely the clothing of these wax models didn't have wax over them,' I mean it just didn't make sense, I remember that. So in my comic books I had the clothes removed. These were not the ones that I showed my mother.

Category i : Books

This category includes the following varieties of books: How-to-do-it books, magic painting books, colouring books, illustrated story books and art history books. Thirty two of the participants indicated that they considered access to books was a significant aspect of their childhood. Some examples of such responses are as follows:

> We had free access to the study, which was where all the books were. From my primary years I remember the books and the old wind-up gramophone. It was a Sunday thing because we weren't supposed to do anything else. I had to ask for particular books and they were taken down - a bit like the British Museum - I was given some books to look at, so that it could have been fairly early - but at least after I had learnt to read I think.

> At home we had these lovely books of drawings, English books, drawings of children, drawings of animals, faces, children and animals. There were three volumes. I think my sister has got those now. But they are all pencil drawings. I copied some of these images.
>
> They had a huge collection of books and as far back as I can remember they had a huge wall of books. We were read to a lot. We were fed a fairly strong diet of Australian writers. Clifton Pugh had illustrated one about a bush fire. Blinky Bill and the whole nationalistic sense of the Australian culture. I think my parents were fairly involved in that because they actually didn't have prints of old masters or anything like that. They had Australian paintings. They had a strong sense of Australian culture and identity.

During early childhood, magic painting books, colouring books, activity books which included experiences such as dot-to-dot, puzzles, and colouring-in were important aspects of regular activity. For example:

> I remember dot-to-dot books and the magic painting books as well. I remember being given strict instructions from my older brothers about how I had to keep the brushes very very clean and wash them in between, the areas so you didn't transfer one colour from one area to another. In their terms it spoilt the final results. I remember just wanting to get the water on as quickly as I could.
>
> I had colouring-in books. I did a lot of colouring-in. I did some cutting and pasting.
>
> I can remember having magic painting books - I think they may have come from grandparents. I don't think mum and dad thought much of them.
>
> Colouring books and coloured pencils were a slightly fringe activity but we were encouraged more to make the scrap books.
> It was an impoverished house hold in terms of money and so the scrap books was an economical activity. Colouring-in books cost money.
>
> I loved colouring books and I had magic painting books too. I used the Derwent coloured pencils for colouring.
>
> I do have one magic memory which was a colouring-in book, I think it was I.X.L. jam. I reckon anything I had was as cheap as you could get and I spent the whole of my childhood searching for that colouring-in book, because it seemed like pure magic to me. I never found it. If I could find it now, it would be the greatest experience of my life, it really would!

For one third of the participants the images from particular children's picture books provided motivational visual influences. For example:

I was certainly interested in drawings in children's books and when I was very young there was a book that we had written by Mary Durack which is an account based on an aboriginal legend and it has very powerful - very beautiful illustrations very rich in colour of dreamtime stories - children being taken down to the bottom of the river by a crocodile - brilliant greens and blacks and so on. There's another one of a whirl wind - very scary, spooky figures .... I remember being electrified by the illustrations of Arthur Rackham.

Coles Funny Picture Book was tremendous, in fact I keep thinking of that now. Do you remember those Gestalt sort of pictures of the trees with the things hidden in the trees and then the mountains and the wicked Serb hiding in the tree ready to kill the poor Turk, those sort of things? Yes, I remember using those images when I was doing drawings after that style. Playing around with those sort of ideas - that was in primary school.

I loved to draw horses which stemmed from my parents reading me the story of *Black Beauty* ... they gave me a how-to-draw book about horses which was written by Charles Keeping. I learnt a lot about drawing horses while looking at the work of Keeping.

There were lots of picture story books around. Yes there were some *Noddy* ones that I was particularly fond of and I think it was the quality of illustrations in those and the wonderful mock architecture. Fantastic colours of the *Noddy* illustrations. There was another book as well that fascinated me, an illustrated book.

I can remember an artist called Rene Cloke. They were these sort of stories. He/she was a good illustrator. They were the black and white drawings generally, but I have seen coloured ones too. The other illustrator I was impressed with at primary school was Thomas Henry - he did the *William* books - I enjoyed the illustrations.

I was fascinated by the black and white illustrations in the children's books ... I particularly remember the comic strip about *Rupert the Bear.* It wasn't so much the bear that was of interest, rather it was the landscape in the background of each comic segment. I was really entranced by the layering of colours which seemed to be used to provide a feeling of depth/ distance in the paintings. In upper primary school I tried to use the same technique as the artist who drew the *Rupert Bear* strip. It was my desire to achieve a feeling of depth in my landscapes by using various colours and gradations of tones in the colours.

There was a favourite picture book called *Pookie* and it's still at home - what really attracted me in those days were the colouring and the detail. Especially the wonderful detail, where you could get totally engrossed in what could be part of that scene. I can always remember that - wonderful books. We'd get books like that for birthdays. It was a real fantasy land.

The book called *Bumble* had a big tree in it that was made into somebody's house and it had little windows all up the trunk and a door. Can't even think who lived in there. I loved that idea of a house in a tree and I can remember working on that idea with my drawings. Things that lived in houses and trees. I thought it was a very exciting idea!

Magazines provided very rich sources of imagery for a quarter of the subjects. The photographs provided clear details of exotic animals and natural environments. In most instances, the subjects had used this photographic imagery during their secondary school years. Some examples are as follows:

> I can remember looking at *National Geographic* magazines .... My early idea of what an artist was included North American culture as conveyed by Norman Rockwell in the *Saturday Evening Post* .... We used to receive *The School Paper* from the Education Department which had engravings and illustrations to the work of Henry Lawson - they were beautiful little prints ... there were quite a few comics in the house and there were lots of books about geography and cowboys - lots of picture books - I liked the illustrations relating to the Kipling stories such as *Kim* - they were engravings.
>
> I was fascinated by illustrations of any sort. I would look through books. We had the old *Strand* magazines. We had a complete collection ... so I would say these illustration influenced me more strongly than my mother's collection of paintings which were just there.
>
> There were two art magazines at home: one was *The Studio* and also *Art in Australia.* I don't know how they afforded them but some of them may have been old copies and my father used to get a magazine *Popular Mechanics* and also an archaeology one which was called *Art of the Past* . He was very interested in Tutankhamen and the archaeology stuff that was going on.

Books about the life and work of artists seemed to inspire some of the subjects. Generally, these were read during adolescence and often were used by the subjects to gain some insight into artistic behaviour.

> I was reading Somerset Maugham short stories. I remember reading books which were a major influence such as *The Moon and Sixpence, The Moulin Rouge* - I even saw the movie. I used to love to read biography.

How-to-do-it books were widely used to assist with the development of technical skills as well as providing a systems approach to drawing favoured subjects such as animals, portraits and cars. The Walter T. Foster books were widely available and comparatively inexpensive. Some examples of instances where subjects had used books with technical information are as follows:

> I also used the how-to books, from a technical point of view. The teacher provided a lot of books with prints of art works for me because of my special love of art.

> I used the how-to type of reference books to acquire knowledge about various techniques. The Walter T. Foster books and *The Australian Artist* magazines. I used the landscape and seascape references in particular.
>
> My parents and friends of the family realised that I was keen on drawing so every Christmas and every birthday I was given a How to Draw type of book. They didn't have much influence on me because I could do the exercises so quickly - animals with two circles approach - I came across the Walter Foster books certainly for colour and brush techniques. I looked at his techniques and I took them on board as I needed them. I sometimes spent a week or a fortnight experimenting but once the skill and knowledge had been gained, I did not open the book again - it was left on the shelf - because it served a purpose and it was probably a very small purpose but it certainly served a purpose and it probably sharpened my focus and awareness. The next time that I looked at a picture I looked and wondered if it had been treated like the examples in the Walter Foster book. I was building up my repertoire of technical skills.
>
> I had books on how to draw and learned a lot of things from them. All this was out of school. I used to hang around in the school library all the time because I stamped around with my head down and my shoulders up and tried to keep out of the way and had few friends who did the same thing. In the library, I would read *Punch* and looked at the cartoons. I loved *Punch* cartoons: Thelwell and so on. I loved pen and ink and the *Punch* style was very influential.

The desire to acquire technical skills also led eight of the subjects to respond to advertisements which were regularly promoted in popular magazines such as *Pix* and *Post*. The advertisements encouraged interested readers to apply to a private art institution to receive an art ability test free of charge. For example:

> I also responded to an advert on the back of a magazine called *Pix* which stated: Do you want to be an artist? You had to copy certain images. One of the images was of a rooster and a chicken.
>
> At home we had a linen cupboard in the hallway and in the left hand door of the left hand cupboard there was a book - amongst other things and they were my mothers. She had written away to do a drawing course which was often promoted on the back page of a magazine like *Pix*. They'd sent her exercises to do - copying exercises - and I remember being quite impressed with the magic little things in there - the art that my mother had done.
>
> I remember drawings of a comic character known as Saltbush Bill. They were drawn by an artist called Eric Jolliffe. They were always at the back of *Pix* magazine. They always had a section at the back where he had done sketches of Aboriginal babies and emus and so forth. I thought that they were really clever and I wished that I could do that.

The black and white illustrations in children's annuals as well as the pen and ink style used by political cartoonists impressed a quarter of the subjects. The cartoons were usually located in popular magazines as well as daily newspapers. Some examples provided by the subjects are:

> My father had books such as *The Quivver* and the *Boys Own Annual.* They were really quite profusely illustrated. I still have my father's books. I used to like looking at them. *Black Hawk* I liked and I used to get the *Champion* every week. I used to hang out for that *Champion,* I loved it , it was nine pence. Mum used to get it when she went shopping and bring it back home. My father used to get the *Bulletin,* and that had wonderful cartoons in it. I was very impressed with them.
>
> When my father was in the army there were year books from the armed services and they had pen and ink illustrations in them. War time comics, illustrations of battleships that sort of thing or the ships sinking. They were Green and Gold books or something like that - and I loved them.
>
> I can always remember looking at those fine drawings in those old books with all the fine horizontal lines, which go fine and thick and then thin and they build up to make a picture. Also fine etchings. So I draw a lot now and it's mainly for sculpture; I never draw for any other reason.
>
> I spent a lot of time going through all his books and some of those boys annuals were absolutely fabulous with all the stories and illustrations. I used to spend hours copying them with paper and pencil. I suppose that's why I began to become interested in drawing and recording.

Six of the subjects specifically referred to the photographs and illustrations in encyclopaedias such as *Newman's Pictorial Knowledge* and *Arthur Mee's Encyclopaedia* as being of particular interest.

> I was a very avid reader. I read every book in the children's library, once if not half a dozen times! And so I think that that was where my, one of my main avenues of retreat were - into reading. And certainly drawing as well but I think the main one was reading. I remember we had a series of encyclopaedias, called *Newman's Pictorial Knowledge* which I actually bought later second hand for my own children because I remembered it, so I have still got it. But I think, I do remember looking over those, probably it would have been at primary school, those pictorial encyclopaedias a lot and one thing I know I did do a lot of and that was copying.
>
> We had a set of *Arthur Mee's Encyclopedia* - so many of my visual memories relate to that set of books - that's what I did a lot of as a younger child. I would sit and devour them - literally! And they had all sorts of wonderful ideas in them, things to make and do.

Category j : Museums and art galleries

This category relates to visits to museums and art galleries including both public and commercial galleries. Twenty five of the thirty four participants indicated that they had made visits to an art gallery or a museum at some time during their childhood. Those who remembered details of their early visits, were more interested in the natural history and dioramas on display rather than the fine arts such as painting and sculpture.

> As children we were taken to the museum at Cambridge. It has a wonderful broad collection. It has wonderful pottery from all periods. It has suits of armour, Impressionist paintings, tombs, beautiful Rembrandts and Brueghels, stunning Titians and works by Veronese and Samuel Palmer. The ones that appealed to me - Samuel Palmer -*The Magic Apple Tree* - at first I was more interested in the armour but I took the other in.

> I was taken to an art exhibition of art work by a Scotswoman. I remember her paintings. I was about six at the time. She had used oil paints and made flower studies beside windows using quite bright colours. The thing that I remember is that she had built up the texture on the leaves and petals of the flowers with the brush strokes. I was quite impressed with how she had done that. The flowers were painted in thick brush strokes and built up in impasto, so that must have had an impact for me to remember that. That was my first exhibition! But I couldn't see the point of it - all the paintings around and I couldn't understand why they were all there together on a wall. People were buzzing around having cucumber sandwiches and glasses of sherry. I couldn't see the point of it. I didn't realise that there was selling going on.

> I went to the Museum and Art Gallery in Hobart and I always went to look at Truganini's bones and the Egyptian Mummy lying in the case under the stairs. I can remember walking around in the galleries and looking at the paintings and wondering how people could do it and how it was done because it looked so hard compared to my own scratchings and the sort of results I was getting on paper.

> Well we spent a lot of time in the museum because that was something that we children did. I don't remember being taken to look at paintings but I must have seen them. I mean, I was aware of all the paintings particularly the ones that were in the colonial section upstairs but I don't remember taking much notice of the modern paintings.

> As long as I can ever remember, I've been going to the museum - it's become part of my life - some thing that's been there all my life and I've been there many times - probably hundreds of times. I not only looked at the art but generally everything in the museum. I loved the carved ivories and those sorts of things probably more so than the paintings and drawings. I have spent all my life going there. I became aware of other things in the gallery when I was quite young. I can always remember those

> old pictures of the colonial period. In the museum, I was drawn to the decorative arts - the aboriginal things and my favourite place in the whole museum was the Chinese Joss House. I reckon I used to spend hours in there just hanging around the Joss house, looking through the window, looking at the carvings and - maybe they were the biggest influence on my ideas and art work more than anything else.
>
> I remember going to the big museum in Brussels, I think I must have been seven years old, with my aunt and I saw Mummies there they had lots of Egyptian artefacts and I also remember the first two years of primary school we lived next to a church and there were lots of paintings there. I also remember very clearly that my parents used to take me to a park in Brussels and around the park there were pillars and in the middle of the park there were pedestals and they had all these life size sculptures of people and my parents would always say how beautiful the sculptures were.

Generally, visits during early childhood and primary school years were made with a parent or some other relative. Rarely were visits made as part of the school program. For example:

> I can remember being taken to Canberra where my father was a politician and I know one of the big highlights that we had to all see there were the Dobells in the War Memorial, which was quite an interesting thing for my mother and father to enthuse about. My mother was certainly very enthusiastic that we should visit the War Memorial and see the Dobells and see how wonderful they were. So I looked at them, but I don't remember getting particularly excited. At some stage I can remember going to the gallery in Hobart, I think it was probably during my time in upper secondary school. In those days the gallery was up some steps. I can't remember what the work was but I can remember a feeling of physical excitement as I entered that room and observing the work which was huge and colourful. It just took my breath away and I felt excited by the paintings. I think that was probably around the time that I was fifteen or sixteen. Strangely enough, before that, probably going back to primary school, I had made my first visit with my father to Canberra and on the way back through Melbourne, he took me to the National Gallery and in one small room there was an exhibition of Nolans. Now these were Nolans from the 1940s and they were the St. Kilda series which to my eyes looked astoundingly strange and goodness only knows what my father made of them. I don't think I liked them in any way, but they were astounding to one's eyes because they were so childlike and not the sort of thing that adults painted to put on a wall. I don't think that I knew what to make of them, but I can remember the look of them and how strange they seemed to me.

Organised school visits to special art exhibitions were more usual during the senior years of secondary school. For example:

> About that time when I was fourteen or fifteen a big exhibition of the work of Rodin came to the Hobart gallery and we all marched along from school. I can remember going back a few times after that just thinking - this is marvellous ... that would have

been the first big show I had ever seen. We went to about three different exhibitions while I was at high school. In those days, art was considered to be very much an additional/optional subject. Many people did not consider that it was a proper subject.

I visited a British water colour exhibition at the local gallery. That was my first real moving art gallery experience and I can still remember those watercolours by Christopher Woods and John Piper. They were exhibited at the Museum, so I must have been taken from school. It was the first exhibition that really impressed me. Although I had been to the Museum to see the animals etc. with Dad on many visits and probably had walked through a gallery, I hadn't really taken much notice of the art.

Eighteen of the participants reported that visits to art galleries, even during the secondary school years were made during out-of-school time. For example:

I saw an exhibition of drawings by Stanley Spencer. But that was right at the end of my schooling. I walked in on the exhibition purely by chance. This was my very first art exhibition.

I went to a Delacroix exhibition when I was fifteen and that made a big impact on me. This was in London. I went with my parents.

I remember going to an American Exhibition, that was a big blockbuster sort of exhibition of American art. And another one by William Dobell and being absolutely charged by that experience, seeing these huge canvases. My mother, I suppose was the encourager of that or she appreciated art and she knew that I was into it, so we would go to those sort of things. I remember those exhibitions because it was probably the first time that I had been to an art exhibition and that was seeing real art as opposed to any prints in books or anything like that although I don't really recall really having art books around the house. It was just, yeah well, having seen those, some of those prints at school, I think I remember being shocked that paintings had brush strokes and textures and the light sort of, you had to stand somewhere to look at a face or something to see because they were shiny and all that sort of thing. And being sort of stunned that they weren't smooth!

I was also very much influenced by Constable. I'd go into the museums and breathe - you have to put your nose out until you can smell the paint - and you breathe it - and I went into the fields as he did.

I went to exhibitions and coastal art group openings [N. W. coast]. During my school holidays I was always playing outside adult education art classes while mum was inside either learning or teaching. I was still going on gallery visits all the time with my parents. By that stage I was being dragged out at night and the next stage I became an art critic when I was in primary school. I can remember going to the Burnie art group, both my parents were members, on regular occasions at night and looking around at the work and then I started having memory that I carried through to my adult life.

Well it must have been during primary school age, I got very interested in museums. I spent a lot of time in museums. Not specially looking at art but beetles and all sorts of things.

I saw a big exhibition called British Painting and the Modern French one so we were taken to those while I was at high school.

Well I know we did go to the museum in Hobart because I so distinctly remember the diorama of the Aboriginal family but I can't remember in primary school. I certainly can't remember any awareness say of the contemporary art at all. I think I was probably far more attracted to those sort of natural science displays than things. The convict room and all the wonderful stories about that. My mother had fantastic stories about that and so did my grandfather. But I don't actually remember with any clarity paintings in the museum context but I certainly was starting to be aware of them in primary school in my grandparent's house because they had quite a lot as I mentioned and art was discussed quite a lot.

I went with a friend's family to a museum while I was at primary school. This was in Brisbane. It was the first time that I had been to look at sculpture, just sitting on the grass and actually wondering about it: How could some one do that? I went to look at the paintings only when I was older. I also went with my parents when I was younger. We went to a gallery and there was a blue painting amidst all the traditional style landscapes. It was a blue face, a blue background, a black plodge for hair and it was worth $3,000 or something. I still remember that painting today. I don't think that it was a very good painting. At the time I couldn't believe it, that someone could do a painting like that ... it was the freedom of expression that it represented. We also went to the museum. We were out all day and we went to about four or five different places and each one was just like a treat.

While Dad was in the services, and we were following him around, staying in lodgings and hotels mum would go to the museum which was a wonderful place to go to to fill in an afternoon or sometimes the whole day. I suppose I did spend a lot of time in places that other children of my age would not have been.

My mother worked at the University so I was able to visit the gallery there and see original works on display. Most of the work seemed to be ceramics, textiles.

We used to go to the Launceston Museum and the Hobart Museum but I don't remember particularly visiting the painting galleries. We spent time in the natural history section. There was a big turtle there and there was a colonial painting with gum trees that looked odd.

I went to the museum with my mother. The memories that I have of looking at the bust of Truganini rather than the art works because the art works were always rather forbidding and rather unattractive I'd say. They just looked dull and uninteresting and threatening.

... took us to the gallery to see some exhibitions. I remember the Dutch Masters. Piet Mondrian - his early stuff as well - the trees - I was very struck - I think it was the first time that I'd seen paintings - lots of them - that I'd seen in books. To see the real thing and to sense the integrity of the work itself which you can never get through prints. I was also struck by the fact that there's a certain quality that was never conveyed in prints. That was the first time that I realised that you can't beat the original. The magnificence of the gift that the artist has which makes the work stand

out. It's such a fine thing that can't be reproduced. Only the original work itself has that.

I also liked Piper's work because you know that type of work that I liked very much and I liked Rodin a lot and I remember him in particular and we used to go - not often - but occasionally to the Fitzwilliam Museum which is a good, one of the good old museums, at Cambridge public museums, which has a lot of work in it which is minor work of great artists. And so I would have seen all those examples of all those sorts of works in the Fitzwilliam Museum. I didn't go there often though because somehow life was circumscribed and....

I think we never went on school trips, even at secondary school, so I can just recall going with friends on a Saturday and I can well imagine that the teacher would have said well you should go and see this, it is in the museum. But not organised school trips. Other than to London once or twice to see dramatic things that were put on, so we did actually, very rarely though, I can remember two, that's all.

Group 4. Technical knowledge

Category k : Copying

This category refers to the technique of copying which was a much used method of acquiring technical knowledge and skill.

Twenty three of the participants indicated that they had copied images from a range of sources sometime during their childhood. In three instances the images which they had copied were taken from popular culture sources such as comics and cartoon characters:

I used to copy the figures from the comics. I was unsure of what to do for myself and there was no one else to draw on so the easiest thing to do for myself was to copy. It was a learning experience for me.

I remember when I was about ten doing lots and lots of cartoon drawings of Tom and Jerry and Mickey Mouse and learning how to draw Mickey Mouse easily like in five easy steps.

I copied some images from comics. I remember doing Jimmy Hendrix T-shirts. There was that famous poster of Jimmy with his Afro hair - and I did that on people's T-shirts. As well I was doing T-shirts for kids of those horrible, horrible tacky images of cars with great big engines and huge mag wheels. I was copying them from comic books; I actually got orders from other children and I guess they were my first professional jobs doing Jimmy Hendrix on T-shirts for people

Eight of the subjects had copied images from a technical viewpoint to enable them to define the details of the subject of their drawing to satisfy their visual expectations. For example:

> I copied a lot. I was very interested in landscapes and still life. I copied examples of the work of other artists .... I copied to acquire knowledge about the objects I was drawing. It was more to do with technique though.
>
> I copied the Norman Lindsay drawings quite a lot. I was really self taught.

Six of the subjects reported having used the reproductions of adult artists as starting points for copying. For example:

> My mother had a book on English marine watercolours and I copied one of them and it sat at my grandparents. It was still there when I was visiting in my twenties. I copied images of fishing boats and seascapes. I was doing things at home like the copies of ships and fishing boats. I also did copies of Cezanne's paintings especially his work of apples on fabric.
>
> The first oil painting I did was a copy of an oil painting we had at home. It was a vase of flowers. I did it because it was accessible and I admired the technique.
>
> I spent a lot of time going through my father's books and some of those *Boys Own Annuals* were absolutely fabulous with all the stories and illustrations .... I used to spend hours copying them with paper and pencil. I suppose that's why I became interested in drawing and recording .... I spent a lot of time copying the images in these books .... I also copied the work of Australian war artists, because dad had the books with marvellous illustrations of the Australian war artists.

Five of the subjects specifically referred to their use of photographs from magazines including *National Geographic*. For example:

> Paintings, blow ups of microscopic images of crystals and that sort of stuff. And alongside that I was copying images from *National Geographic*s that I really liked including figures.
>
> I can remember copying photographs from magazines. Different heads and hands and things. These were done in response to homework requirements. What I should have done was go outside and draw what was out there but I didn't, I just used a book. Everything was easier because the images were in two dimension.
>
> I remember spending a lot of time going through graphics magazines and design magazines. I was constantly looking for ideas, looking for something to sort of, to

> pin a making activity around, looking for an image as a starting point. I remember the teachers saying you have got to develop your ideas whereas your ideas had come from the use of magazines such as *National Geographic*.
>
> I didn't copy the work of other artists so much as copy images from wherever, from - *National Geographics* were a real source. I spent lots of time looking at books rather than reading books. I loved general knowledge.

Twenty two of the subjects indicated that the activity of copying was carried out in the home environment:

> ... and one thing I know I did do a lot of and that was copying. It was at home that I remember doing it. I don't ever remember copying at school.

However, in a school setting, copying was an accepted aspect of art history. Teachers often expected students to copy images of architecture or sculpture into their art history notebooks. This activity was somehow seen to be different to the actual art making lessons. Copying was also an integral part of other subjects such as Social Studies or History and Geography. Some typical responses relating to this aspect of copying are:

> In the little Atlases that we had, there were tiny pictures of things like: where the coal is mined at Yallourn and there would be a picture of an open cut mine with tractors and trucks down there and I remember copying a picture from one of these Atlases ... it was in oil pastels and I had actually drawn the picture with black first so I had gone around the outline and copied it with black and then I'd used really bright colours on the truck ...
>
> Those kinds of drawings involved copying things and for art history we had to copy images ... but we learned some drawing skills through this process. Art History at high school was a lot to do with architecture and archaeology. We had to copy from some of the little black and white photos in the text book.

Some subjects referred to specific instances when they were required to copy paintings as part of their art history lessons. For example:

> We learned to use the traditional egg tempera technique and we had to copy a painting. I had to copy a Kandinsky which was incredibly difficult ... there was a Morandi painting too.

Category I : The influence of an artist

This category refers to influence of the style, technique and/or subject matter of a specific artist. Thirty one of the thirty four participants made reference to the impact of the work of at least one specific artist. In almost all cases, the influences occurred during the time that the participants were students at secondary school. Some examples of such an influence are as follows:

> The work of Cezanne was a very early influence along with that of Rembrandt. I was also very much attracted to the work of Mondrian. His use of colour was a particular focus for me.
>
> I was influenced by Delacroix quite a lot - I used to do battle scenes with people being torn off horses for quite awhile. I loved the vigour and the colour, the use of strong primary colours and the interlocking figure shapes as well as the restlessness and energy. I've still got some of the drawings I made at that time.
>
> I started doing Rousseau-like landscapes of forests and tigers and ladies bathing in pools. It was at that point that I decided that this was what I wanted to do.
>
> I was influenced by the work of Braque and Picasso because they were formalists and when you are that age you want - you like the seduction of the formula. It makes things much easier for you, it's a way of learning to simplify, but in the end it can become mannered. It's a very effective way of teaching yourself the rudiments of painting.

One half of the participants were made aware of the work of the specific artists as a direct result of formal art history lessons.

> My mind was really open and most of the historical artists I studied had some influence on me. My mind was open to everything. I think I was probably influenced in some way by every artist we studied.
>
> That was when I got my first taste of the work of the Impressionists which was through the history component of the course. I thought that their paintings were fabulous. I was quite mesmerised by the colours. I read a lot about their lives and work after discovering them in Art History lessons.
>
> I can remember going home and trying to do something similar to Degas - you know with his ballet dancers. I tried to get that same sort of technique. I copied Degas' ballet dancers. Van Gogh was high on my list of models as well - his paintings - they were the two main artists. I bought some prints too - I bought some Van Gogh prints. I liked the landscapes by Constable too. I liked the look of the English countryside which he portrayed in his work .... Van Gogh's colours and the use of colour by the Impressionists were very significant influences..

> The Fauves and their bright colours and the Impressionists were studied and we had to know all about the influence of the development of the camera. There was Cezanne and I was always impressed with pointillism as a way of putting the paint down. Cezanne particularly because I liked his colours and things and I liked going to the bush and I liked his subjects like *Rocky Scene near Aix* and it was the first time that I thought there was a system - that art had a system.
>
> I was particularly fond of the work of Vlaminck ... expressionistic portraits of people. Like just imaginary faces, that is what I liked doing. But I wasn't allowed to do them to the exclusion of these other things. I was rather fond of William Dobell because he would have been one of the few Australian artists that we knew about or were talked about. Yes, he was one I greatly admired.
>
> The work of Monet, Manet, Utrillo, Renoir, Gauguin and Van Gogh all influenced me to some extent. I remember copying some of the paintings of Utrillo. I was attracted to his style. But because I had not been taught how to mix colours I became very frustrated when I attempted to match his colours.
>
> I liked the work of all those English artists, you know - Constable, Gertin and Coatman and all those. I also liked Millet's work and some of the Pre-Raphaelite paintings. I thought that the painting of *Ophelia* floating down the river was wonderful. Later on I was influenced by the work of Aubrey Beardsley and the Art Nouveau style. I was very impressed with Turner's work - it was the drama of his seascapes - I tried to imitate Turner's style but of course when you are using water colour it doesn't come out right.
>
> I loved the work of Michaelangelo, Raphael and my art teacher always had books on his table. We were able to take the books to our desks to look at them. It wasn't long before I was buying art books because of his influence. The books that I bought were to do with the Renaissance due to the influence of my teacher. I have many books about Michaelangelo. I spent a lot of time copying the images in these books. This was when I was about fifteen. I spent hours and hours. Perspective fascinated me, and the foreshortening of the body parts - I spent hours trying to match his skills and attempting to work out how he did it. I would look at the Michaelangelos then I would go away and draw Superman flying through the sky, but I dare say it's all part of the process of acquiring skills and a visual language .... I began to look at the work of the French Impressionists - and most people seem to go to the French Impressionists - and I was no different to anybody else and I liked Australian painting - the Australian Impressionists, and I still do.
>
> I could talk about artists like Modigliani in about Form 2. I was very excited about the whole thing. And I remember also that the images, particularly by Modigliani were totally fascinating. I mean the other kids in the class found them amusing. I just looked at them and thought they were magic pieces of work.

The art work of the Surrealists, and in particular the work of Dali, was identified as being a significant influence by many of the participants.

> I was really in love with the work of the Surrealists and I think Dali was my favourite painter in Year 12. We thought his paintings were neat and smooth because we only ever saw them in reproduction in books. Just that wonderful sort of graphic,

> figurative work ... they were skills that inspired me .... I remember some of the European Surrealists whose work had an impact on me. I remember admiring Magritte's work.
>
> Salvador Dali was the artist who really rocked me when I first saw his work in high school. I instantly made a connection to it. I know, now that I'm an adult, why. Since I was a child, I've always had an interest in the esoteric and I never understood why and I never even realised that until I was an adult leading towards things that were a little bizarre. I read books about witches and ghosts and things like that as a child. My taste in art has always been to the Surrealists.
>
> I loved the work of the Surrealists and people like Rousseau and the Flemish primitive paintings. When I was doing interior design I went to Amsterdam and there was a really big exhibition of the Bauhaus. I started doing sort of surreal-type paintings around that time. It was perhaps more Symbolist painting which was just something that I felt rather than an influence from other work.
>
> I loved the work of Salvadore Dali, and I read his autobiography and the man was a psychological freak and very bizarre and I felt a strange attraction to his work.

The paintings of Van Gogh were widely identified as being very influential. As with other artists, the participants were influenced either by the techniques used by the artist or they were very keen to learn about the specific content such as human figures, faces, animals or trees by referring to the content of the art works. Some examples provided by the subjects are:

> Van Gogh's *Bedroom at Arles.* I remember it was in one of my books, it must have been when I was a little bit older and I thought it was wonderful that someone could draw a bed like that and use those colours. That particular use of perspective and all the wonderful colours and shapes were just simply the most extraordinary thing I have ever, ever seen, and so very different to the art that I was brought up on with my grandfather. So the work of Van Gogh made an enormous impact on me.
>
> I loved the work of Modigliani. Van Gogh was another artist whose work I admired. I guess my teacher showed me a lot of his work and they are probably the only two that I really remember from my early secondary school days. Modigliani in particular- his sculptures and his paintings. I remember them quite vividly. I can still see them. I referred to their work particularly in relation to the sculpture. I studied Modigliani's because I started to carve figures and heads that were very elongated. And some of my paintings were heavily influenced by the work of Van Gogh with his kind of movement. So there were obviously very big influences from both artists.
>
> When I saw Van Gogh's *Sunflowers* (I'd heard about Van Gogh from my teacher) I lost my breath and then I got very annoyed because I saw that he had used thick paint and I thought that I was going to be the only person in the world who, when I started painting, was going to use thick paint.
>
> I was very impressed with the paintings by Van Gogh. When I read his story and found out about his life on the coal fields and how he was treated as a missionary

> and how dedicated he was to his art and how the poor wretch only ever sold one painting - it made a terrible impression on me - you know: What's life about? This man is an artist! I thought: what a wonderful person he was apart from his personal problems.
>
> I tried to incorporate movement qualities and colour in my work in particular that I noticed in the work of Van Gogh. I was very influenced by Christo. I was covering natural things with dyed and macrame fabric - very 70s. They were tactile fabric type structures that I focussed on. That was the field that I was hoping to move into more - the fabric structures. Christo was probably the first conceptual type artist that I'd seen. I was quite fascinated by it. I was also fascinated by the Futurists and the Expressionists particularly Frans Marc, Auguste Macke - very strong forms in the colours that seem to be the reason I was drawn to these artists.

Eight of the participants were exposed to the work of historical artists in their home environment. This exposure was usually possible where one or both parents were involved to some extent in art making or where they were interested in art from an aesthetic view point. Two examples which specifically referred to Australian artists are as follows:

> We had some Glovers and a Gladstone Eyre painting. I liked them because mum and dad liked them. I think that the more detail there was in a picture, the more I liked it. We had a Forrest so I would hear how beautiful a particular painting was. Visitors to the house would be shown particular works and I would overhear conversations and discussions.
>
> I fell in love with Norman Lindsay's work again, an adolescent fantasy and fabulous technique. We had a family connection with Norman Lindsay in that my mother's cousin was his doctor for many years. He had a fabulous collection of work. Norman sometimes paid his bills in paintings and gave them as Christmas gifts. They had twenty or thirty Lindsay's. He had a sense of humour as well. I copied the Lindsay drawings quite a lot.

Group 5. Socialisation

Category m : Isolation

This category refers to the isolation of an individual from a peer group. During the course of the interviews and later, as a result of data analysis, the researcher found that twenty of the subjects had been isolated from a peer

group in some way. Four of the situations which had impacted on this sense of isolation were:

1. The subject was isolated through the geographic location of the family home.

2. The subject was an only child.

3. Where there were siblings, there was a significant gap between the birth of the siblings and consequently the subject had been raised as an isolated child.

4. The subject had experienced periods of debilitating illness which had necessitated their being isolated from other children. In some instances, the illness had been constant, in others infrequent while in other cases, the illness had occurred only once but for a sufficient period of time to have had an isolating effect on the subject.

Some typical responses which emphasised geographic isolation were:

> During my early childhood we lived out of town on a farm and there wasn't a lot of connection between me and the rest of the world at all until I first started school ...
>
> We lived in the country .... It was during the war so there was very little contact with anybody else, in fact no contact with other people making art .... My mother didn't like us being at school more than we had to be there because she thought the kids were rough and we used to walk to school and I can always remember walking miles behind - I was always interested in looking at things ...
>
> We lived in a tiny rural village. A very remote village and we had very little communication with the outside world
>
> We were isolated from other children so these [art] activities were personal. We couldn't associate with the village. There were great high walls around the compound. We could hear them and once I climbed to the top of the wall and talked to an ... boy but that was the closest I got.

Ten of the subjects indicated during the interview that they were only children. This isolation from other children placed them in a situation which left them to their own devices as far as play and exploration of their home environment were concerned. Some typical responses from subjects who were raised as the only child were:

> I had a very separate childhood ... there wasn't a lot of interaction with a lot of other people apart from playing on my own with a lot of grown ups who were my mum's ilk.
>
> I see myself as an isolated figure in an environment which was sometimes a little bit rich, but my whole feeling about it was of absolute deprivation ...
>
> I was an only child and probably a bit of a spoiled little boy that got his own way. I was a bit of an isolate because I played on my own a lot. I spent a lot of time indoors.

In other instances, subjects were raised almost like an only child due to a significant gap in the birth of the siblings. Some typical responses under this category were:

> I did a lot of work at home and I started oil painting, My parents were happy that I kept myself busy. My parents were both working and by then my brother had moved out so I was on my own and maybe I drowned my sorrows in my painting.
>
> I have two brothers. I am the eldest. There was a big gap due to the war. I was almost like an only child ... at the time it didn't dawn on me that I was different to the other children. I was a very sensitive child.
>
> There was a large gap between the birth of my sister and myself, consequently, it was like being an only child. I always made the comics on my own. I used to run off and hide somewhere and make the damned things and as soon as my father came near I would hide them (the comics).

A fourth issue which led to the isolation of many of the subjects was some kind of childhood illness. For example:

> I was quite ill with asthma and bronchitis for much of my school life and so my schooling was rather fragmented. This meant that I spent a lot of time by myself in a withdrawn kind of situation .... I was in a situation where I had to entertain/occupy myself so I drew and drew and read lots of books and comics.
>
> And the other thing I did was sewing. I would do drawings ... it was something I did. I remember doing those when I was sick. I would do a drawing on a piece of cardboard and then I would sew. I got chicken pox twice - and tonsillitis quite a lot too. I recall filling hours drawing in bed ...

One of my vivid memories is drawing on the wall next to my bed - drawing a train when I was a very sick little girl - when I was about four ... I used to draw with black lead pencils and some coloured pencils.

I was quite ill as a child. I had quite a lot of time at home off school ... I spent my time drawing ... I used to draw faces - like people and faces mostly.

When I was about seven, I got meningitis. I was very ill ... I got pneumonia shortly afterwards and I developed chronic asthma. I spent a lot of time in hospital or in bed at home and I started to draw and that leads me to think that I was already drawing - I'd paint and make things. I can remember just listening to the other kids playing on the road while I was in bed sick. I think that's when I was first conscious of making pictures as being an important part of what I was doing.

I spent a lot of time in hospital right through my teens. I remember another kid that used to draw a lot and we used to sit next to each other in school ... the bulk of my art making activity would have been untutored and at home ... probably if I had never been sick then things may have been different.

I had double pneumonia a couple of years in a row. I was very ill. I used to cop pneumonia every year. I was sort of a sheltered child - kept away - wrapped up - and sort of pandered to a bit. Consequently I got quite good with my hands at doing things.

Category n : An outsider

This category refers to the sense of being an outsider in social terms as well as perceiving oneself to be different from others, particularly within a peer group. Twenty two of the thirty four participants indicated that they had, at a quite early age, felt that they were outsiders, that is that they did not feel part of a group. This feeling of being an outsider was associated with the overwhelming desire to make art. Making art was one of the most important activities in the lives of the subjects.

At school I didn't have any peers who were involved in art making to the same degree as myself. I was a one-off person.

I didn't have any close relationships with my peers through art.

During my secondary school years, the only time I spent a lot of time with other people was at school. The rest of the time was very much on my own, I guess I still am a bit of a loner. Making art seemed to put me outside of the main group even more because I wasn't involved in playing football, playing cricket or any of those matey activities. I preferred to be off doing something else like making art which was

> more interesting to me. So there was nobody that even figures in my mind who was supportive.
>
> I spent a lot of time on my own and maybe I drowned my sorrows in my painting.
>
> I see myself as an isolated figure in an environment which was sometimes supportive of my interests, but my general, overall feeling about it was of absolute deprivation.
>
> I can't think that anything that anybody ever told me at school about art ever had very much significance for me at all. I mean I think it was just fairly irrelevant.

The participants reported that they had felt isolated from their peers or their siblings because they seemed to have had a different way of interpreting the world and that they preferred to spend their time making art, reading books and collecting things. For example:

> I was a loner as a child all the way through school. I was in a situation where I had to entertain/occupy myself so I drew and drew and read lots of books and comics.
>
> All my friends at that time were in the science group and they basically didn't understand what was going on in the art area. It was a big joke - you know: they'd say to me, 'What are you doing art for?'
>
> I didn't have friends who were interested in art. I was an outsider, a loner. I was not good at games although I tried but I was not good at all.
>
> I don't recall any of my peers who were as interested as I was. They'd talk about poetry but not about art. I was getting interested in painting but it was a lonely thing ... making art is a very private act.
>
> It was a boarding school stuck in the middle of the country. I found it depressing - and I felt a complete outsider there.
>
> I was really working in isolation. I made efforts to play sport with everyone else and get some sort of confirmation of who I might be through those other activities but I was pretty mediocre at them. They certainly didn't compare with the pleasure I got from being able to make a drawing and have a sense that I represented something in a certain way.
>
> My art making was totally personal. I never discussed any of it with anybody. My one close friend that I went through the senior school with didn't do art. I was reasonably friendly with all the children in the class but I don't remember any of them ever discussing their art work.
>
> I was very much on my own because there wasn't anybody else at school doing art. I felt different. I was quite young - a long way back - when I decided that I wanted to do something connected with art but I didn't really know what it was except that I really enjoyed painting.

Six of the participants reported that they were actually taunted, teased and, in some instances, physically bullied by some of their peers because of their individualistic preferences. Typical responses relating teasing and other abuse are:

> I remember getting into terrible fights with some of the snobby children who referred to others as 'common'. I had this very strong sense of justice. I was quiet, I wasn't boarding school material anyway. I was quite an outsider not only because I was so interested in art but also because I was very critical of others who bullied children who were somehow different.

> I had no friends in my peer group at school. It made me socially fairly mature. I didn't really have a peer group that I was involved with - I was quite isolated which is probably why I didn't like school. I didn't mind being an oddity. That is why I enjoyed art because it was something that I made well and it boosted my self-image.

While the sense of being an outsider often isolated individuals in the primary school setting, at secondary school, they sometimes discovered other children with a similar devotion to art making. Some examples of responses reporting on the issue of being an outsider are:

> I was bullied a lot when I was at primary school. I did not have any peers who made things with me, because I didn't do the things they did- I was the odd one out. It was not until I got to secondary school that things started to turn around.

> Both of my brothers were always out in the shed making things mechanical .... I never had any empathy for anything mechanical. All of my brother's friends that I was exposed to had done exactly the same thing .... There was just this expectation that I was going to be like my brothers, ... I just always knew that, no, I just knew that the shed bored me - where things would be made, where people were working on motorbikes and welding and things. I just had no empathy for a trade at all ... after Year 12 all of my desires were all in art making, that's where the strength was.

> Some of the stories such as *A Lust for Life* would have given me an idea of the Romantic artist who lives in a garret. So that was how I imagined an artist behaved and generally related to the world, but I didn't know any artists at that time. Artists weren't seen to be quite respectable you see. It is a part of every adolescent's view of themselves - to some extent at least - you know - me against the world sort of thing - one's view of oneself as being apart from the mob.

> It's quite amazing because the stuff that I used to like doing which was pictures of people and things - you know - sort of observational and almost narrative - I would have been doing that at high school if it had been accepted by the teachers. That would have been my choice of what to do but we were set off in another direction of what we were allowed to do - you know - landscapes and still life.

You were considered a little odd if you did art and if you did art of speech as well it was a very strange thing and that was me!

I come from a working class background. I lived at ... which was a pretty rugged area, socially. There was a lot of pressure for me to get a proper job - a real job and I think that the compromise with my father was that with art I could probably be an art teacher.

I was really shy and I didn't like talking to other people very much - I liked to paint pictures and generally spend my time making art. I felt isolated - like a bit of an outsider. I had never met an artist and I thought that teachers didn't make art either. My art teachers never showed me that they did.

I wasn't doing the sort of things I was supposed to be doing which was pretty landscapes - they were trying to teach me that - because that to them was art ... it was pretty much an isolated activity for me ... so there was this private little world which I was involved with figures and the ego image and things like that. These were not done at school, I would have been exposed at school ... secondary school for me was - well I just wanted to go at age twelve. It was leaving home - I feel that I left home at twelve, which was really important to me because my secret life didn't have to be so hidden.

There were no other children at primary school who were interested in art in the same way as me - I was a freak ... in first year high school I still was on my own then and I was still the class freak.

Well, I was a muscle head and a wimp because I was hopeless at school sports and I hung around in the art room - I couldn't win either way so I cultivated both. I had no notion of what it would lead to and I think that the fact that I was good at drawing probably served as an escape for not being good at academia and impacted on my studies because I was going to be an artist - therefore I wouldn't need to be good at anything else and I didn't concentrate on studies at all.

Category o : An artist as a role model

This category refers to the subject of artistic behaviour including such aspects as how an artist actually works, how an artist dresses and how an artist lives. These attributes or characteristics were all important to some extent for twenty of the thirty four artists. Some typical examples of the influence of an artistic role model are:

The only way I knew how George painted was because somebody who'd had their portrait done described George at the easel - and it was a revelation - because she

> said that he'd stand well back from the painting and his eyes would be rather dilated and then he'd pounce on it and work furiously for a few minutes and then he'd stand back and then he'd paint a beautiful head and then he'd come up with a cloth and rub it all out again. But he'd just be rubbing it in and then he'd start all over again - it was a very physical thing - and it is - this is the reason why it is hard to work in the street. I always stand, especially for the large works - but for still life I usually sit down - when I'm working on a portrait I prefer to stand especially if it is large.
>
> I had quite a romantic impression of what an artist was and I felt that my talent and capabilities just didn't fulfil what my expectations of an artist were at the time (this was at primary school). I don't know how I had come to formulate the image of what an artist is. Later, at secondary school, I had come in contact with artists with the realisation that art teachers could actually be practising artists; I mingled the two together.

Because most of the subjects felt that they were somehow different to other people they needed some personal reassurance about the powerful inner need they had to make art. For example:

> At first I didn't know that there were artists. And when I heard that there were not only artists, but art schools, where these artists went, I couldn't believe it. I didn't know anyone in the world wanted to do the same sort of thing that I wanted to do and as for having a school to do it, seemed strange.

In the secondary school setting, often a role model was presented by a senior student. This was particularly the case for the male subjects who often felt isolated from their peers because of their interest and involvement in art making. For example:

> There was a bloke who was a year ahead of me when I was in the senior school. I found him to be very interesting. He was very tall and handsome and competent. He was very confident and made interesting 'Whiteley' sort of paintings.

Information from books particularly the biographies of famous artists were read with great interest by nine of the subjects. For example:

> When I was about sixteen, I read a Thames and Hudson book about William Dobell: I was sitting at the kitchen table and I said, 'I want to be an artist'. It was as clear as that. My father said, 'Don't be stupid!' The idea had come to me through books and magazines and second hand sort of sources like that really. I was being discouraged from it by my parents and by my father in particular and my grandfather even more. He said he'd lived through the Depression and he said that everyone should have a

> decent job and you should have a decent job and the expectations were that I'd be a naval officer or something.
>
> The only model I had of what an artist is was gained from reading books. It was all second hand knowledge about what an artist was.

The role model provided by a secondary teacher was often the most significant influence for nine of the subjects. Some typical responses concerning the role model provided by a secondary art teacher is as follows:

> I used to idolise my third art teacher ... his enthusiasm and love for what he was doing eventually rubbed off onto the students. He was dedicated to his work - teaching art to children. My teacher was the biggest influence on my life at that particular time because he was a very courageous man. I idolised him because of what he had been through and what he had done. The stories associated with him and the production of the art work at that time - to a fifteen year old was absolutely incredible. It was magic. The public was saying this too, and I thought, they must be right.
>
> We actually saw our teachers making art at secondary school. The classic example was when Queen Elizabeth II and Phillip visited and we decorated York Park. My art teacher did all the banners and all the signs and he had all the children painting all the banners. This was the first time that I had seen groups of children standing around painting. He would draw the images on a piece of board as quick as a flash and the image would appear as if by magic. This was the first time that I had met somebody with the ability to make immediate images. He was excellent at doing caricatures. This was very impressive to a fifteen year old.
>
> I had a good teacher at Matric. She was more technically knowledgeable. I actually started doing quite good oil painting. I was doing a painting that took me a couple of months which was done purely with the old acrylics and it wasn't too bad. She showed me how to actually paint. Because up until then I really didn't paint. Nobody had shown me technically how to go about painting. She was probably the first real art teacher. All the others just gave projects and let us go on and say, 'Oh, that's nice'. She was the first to show examples and help with perspective.
>
> ... was a big influence on me. He arrived during my senior years at the school. He'd been through art school in Hobart so when he came he knew about art .... He had clay bins and he'd let us muck around with clay. He even encouraged things like plaster casting. He had a good knowledge of history of art and he taught it you know. He was able to make it come alive ... encouraged a love for the subject which ... and I still have. I think really it was his influence on all of us which made us want to go to art school. I made my decision to make art my career in my final year at school - because of (his) influence. He gave us oil paints to use, so we did lots of painting as well as 3-D work in clay and plaster. Real artists did this sort of stuff! I can remember ... making art in front of us. He painted quite a bit in the class room. I remember him making a large head in clay which he later cast in bronze.

> The woodwork class was fantastic because it wasn't in the school. It was out at a workshop with a wonderful craftsman. I developed a very close relationship with the teacher. I was his favourite student to the extent that I used to go on Saturday afternoons as well. I started by going Saturday afternoons in D class and in C class too although I was only able to do woodwork at school in E and D class. I used to pack up the workshop for him and make sure that everything was put away in the garage. I had a great depth of admiration for him. We were in the woodwork shop of course but he had another workshop where he did his casting. That was a fascinating place with all his casts and things. He had a very strong influence on me. It was his philosophy, his craftsmanship not so much his style because his style was outdated but I also had a deep admiration for his three-dimensional skills - I could appreciate that he could see around things and see into things, also the way that he insisted that a job be absolutely perfect.
>
> And the strongest role model that I built up was a high school art teacher. So I became a high school art teacher! Next year I went to teachers college and enrolled in a secondary art teacher course.
>
> But I gradually started to get more and more to the point that I wanted to actually be an artist. I didn't know what it was about and I didn't know what it entailed. And certainly there weren't the kind of positions available within the arts that there are now. So it was kind of narrow I guess. I mean I would find house paints at home and just pilfer them and use them but my art teacher also encouraged me, I mean she would get things for me. She would show me a lot of techniques and examples from books. She was one of the pivotal people of my life. There wasn't much around to support or encourage my interest in art, but she was the one I think who introduced me and taught me a lot about those artistic skills.

The issues of artistic behaviour and dress usually became significant for subjects during adolescence. Consequently, the lifestyle of an art teacher including dress and general social behaviour was significant for many of the subjects. For example:

> The teacher that we had was the prototype of what you would call an artist. He was quite tall and he had, for those days, quite longish dark hair and a big beard and he was quite a big man and he sort of had that real artistic figure. To me that was what an artist was. I did not see him working, but when I was older I saw his work and I ended up working for him when I was eighteen or so.
>
> I remember the art teacher being a really keen surfer. He was interested in all designs and all of that sort of thing. Like designing a surf board in exactly the same way as my mates thought about sort of designing, having a tank of a motorbike.
>
> I had two fantastic teachers for both years - a male and a female both of whom I think actually practised their own art as well. I have met them both again within the last five years and they are both still teaching full time. I felt like that they were artists. They were both quite outrageous in lots of ways compared to the other teachers and they were very outspoken and very liberal in their views. That was just lovely at that sort of age because all the freedom that you wanted was there. The two teachers were my role models as artists but I don't ever remember seeing any of

> their work. I know one of them was a painter and I'm not sure about the other one but I think certainly as characters as personalities they were probably a strong influence because they were both incredibly lively and they said what they thought and they were just very much at home in themselves and that's such a strong memory for me that they probably stood out amongst the field of people who were forever saying what they should say rather than what they actually thought. They could dress how they wanted and ... always had dyed hair and I think I was very very reserved. I had been the oldest child of three and incredibly shy and I had a younger sister who was very out-going and very sociable which always made me feel even more shy and so I think probably I was really attracted to their outwardness and their ease in communication and just their liveliness.

For one subject a major role model was a martial arts teacher. The underlying philosophy about life generally permeated his approach to the sport which in turn directly impacted on his art work.

> My Aikido master was a strong influence on me. He was the person who taught me [about] art but he never taught me art. There is a close connection between art and martial art in that it has a lot to do with dance and you interrelate your mind and your body; you're moving through time and space; you have to create a harmony with the things that are around you; you have to assess situations and respond to them; you may be repeating something that has been done before, but because the situations are different and changing every time, you have to create uniquely and afresh each time. Ultimately you have to move in a way which is intuitive yet conditioned; you can't be laboured and fixed, you have to be free and floating and yourself. You have to be able to know yourself intimately; you have to see your activities be one where you meet yourself face-to-face and if you can't face yourself face-to-face, there's a problem. You have to know yourself very clearly and every time you work you meet yourself very clearly. Now the other thing is that in the Orient, I believe art is taught in much the way that Martial art is taught and that is you take a master because you see somebody whom you aspire to - you feel it physically, you feel it spiritually, you want to do it, you must do it, you fall in love with it, this person epitomises that and you then ask if you can be taken on as a student. You then do exactly as you are told, you repeat exactly what you are shown despite the obstacle; for years and years thinking you're only learning to clone them but in fact because you're different you can't possibly clone them and ultimately realise you've been given everything and that you are set totally free because you've developed a new naturalness which you didn't have - the thing which started off as a technique becomes an extension of you and you are set totally free. If you look at it summed up, in the technical sense of the medium that you're working with you are taught the fundamentals of the medium from the basis up, no questions asked; do as you are told; this is what went before you; this is what you'll need for the approach which frees you from any need to express yourself creatively from any other obligation than simply getting on with the task and ultimately creates a new you and you realise then that everything is creative. You have to create yourself afresh every day. So that's where I learnt about art and that in turn took me to Japan. There I discovered the Japanese gardens and everything else and the interrelationship of all the arts. That's where my life really became and so I ended up a Japanese artist and I am unquestionably a Japanese artist rather than an Australian. That was my real art training. That was the most profound influence on my activity as an artist - it was that that set me free to become an artist because

prior to that I was pigeon-holing art, but now I feel free to be myself and I'm just an artist because I'm an artist. I'm a painter because I'm a painter.

Group 6. School influences

Category p : A teacher

This category refers to those subjects who were encouraged and supported by a sympathetic teacher. Twenty seven of the subjects interviewed mentioned the impact of a teacher. In most cases these teachers were encountered at secondary school and usually they were specialist art teachers who had empathy for the subject's need to make art.

I remember my Matric teacher very clearly. He was a strong paternal male figure. He had a very generous personality. He helped me establish credentials around my interest. He confirmed that I could be an artist.

He was a wonderful teacher in that he allowed us to try all different things like sculpture - cast work which was new to us and he encouraged us to use different finishes on our work - this was in Grades 9 and 10. We were encouraged to experiment with the various media ... he really extended our understanding of what art is.

I used to idolise my art teacher. He was dedicated to his work - teaching art to children .... I followed through into art as a career because I got on so well with the art teacher. My art teacher was the biggest influence on my life at that particular time because he was a very courageous man. I idolised him because of what he had been through and what he had done. The stories associated with him and to produce the things he was producing at that time - to a fifteen/sixteen year old his work was absolutely incredible. It was magic. The public was saying this too and I thought they must be right.

They [the art teachers] were very encouraging and exposed me to all sorts of new materials, different colours of paper to work on and really opened my eyes in lots of ways to what art could be, so I owe an immense debt of gratitude to those classes that I had with my art teachers - they were really great.

My art teacher in senior school was a big influence on me. He had a good knowledge of history of art and ... he was able to make it come alive. He encouraged a love for the subject which I .... still have. He used to take us out of school. He

> used to hire a van and we'd all go and dig clay somewhere .... We had involvement in so many aspects of art making. He took us painting ... we did watercolours ... he also encouraged figure drawing .... It was a great introduction to art school. It was so different to what I'd experienced in earlier classes.
>
> I had a good teacher at Matric[ulation]. She was more technically knowledgable. She showed me how to actually paint because up until then I really didn't paint. Nobody had shown me technically how to go about painting. She was probably my first real art teacher. All the others just gave us projects and let us go. She was the first to show examples and help me with problems I was experiencing with perspective.

Teachers who were identified as significant had allowed the subjects to use an art room at lunch time and other out-of-class times in some cases even at the weekend. For example:

> At secondary school I had a very good art master ... he was a sculptor. He was long, gangly and balding. He was the only alternative figure at the school. He lived in a big house away from the place and he was never really part of the school. He was very encouraging. He made materials available outside the formal art class time.

In five instances, the teacher supported the subjects in their desire to pursue art as a career when there was opposition from some members of the subject's family. Here are two such examples:

> I had a couple of art teachers that I really liked. One guy I got on really well with, who was really supportive ... and we had a young art teacher ... who looked fantastic ... she had amazing clothes and she took us outside to draw. We'd never been outside to draw in the country. She had a lot of interesting ideas and she basically took me under her wing and looked after me
>
> My art teacher gave the notion to my parents, particularly my father, that art was okay. There is nothing wrong with it. I remember being told that I had to leave school by my father and get a job and all this kind of stuff. My art teacher supported me through that and tried to talk him out of it, tried to make him understand.

The art teachers often represented a behavioural role model in the way they behaved, dressed and made art. For example:

> I remember there was a group of young people on the art staff when I was at high school. They were a bit more fascinating - a bit more mysterious ... they were people who wore their casual clothes ... the principal was giving them a hard time about

how they looked as much as the principal was giving certain students a hard time about their behaviour. I always remember the art room as being a comfortable space and the teachers being very relaxed ...

I saw my art teachers making art. I was working with the painting teacher who sort of worked ... like Rousseau ... really lush greens. Sort of idealised vegetation in a tropical setting ... he used to have a picture in the classroom that he would sort of be working at and we would be able to watch his progress.

I had two fantastic teachers ... it felt like that they were artists. They were both quite outrageous in lots of ways compared to the other teachers and they were very outspoken and liberal in their views. That was just lovely at that sort of age because all the freedom that you wanted was there.

I can remember in secondary school meeting the first art teacher that I had ever met. He didn't stay long and he used to sit out on the steps and play his guitar and sing. We were allowed to paint and do all sorts of things. My subsequent art teachers were totally different - they were unique people. It wasn't until later that I fully appreciated their uniqueness.

Four of the subjects developed very close relationships with a teacher and were sometimes invited to the teacher's home environment. Some examples of this support are as follows:

Because I was very good friends with the daughter of my art teacher, as we moved through in to the upper secondary I got to know ... on a personal level. I visited her house. ... was a person who had passionate involvement with art making and it just didn't stop at making pictures, it was a lot about exercising an aesthetic judgement about all sorts of things that came within your experience of life so it was about design of household things like cups and teapots and in one way and another this was something that transferred itself to the students ... these were ideas that I'd never considered - had never been spoken of anywhere around me - the fact that a teapot could be beautifully formed and that it could pour beautifully and this was because the designer of the teapot had made it right.

When I was sixteen, my parents moved and I lived with my sculpture teacher and that had a really big influence on me because he used to take me to all the openings of the exhibitions ... it was like all the top artists who had exhibitions and that was a big influence on me.

I used to go down to her place [the teacher]. I found that experience very challenging because she was the first one who really introduced me to conte, oil paints and the work of other artists. She was a jolly good teacher really. I went over to visit her on a couple of Sundays and we worked outdoors. She was quite a big influence on me.

Five of the subjects were given special privileges such as access to the art room and art facilities during the school holidays. However, this situation only applied to subjects when they were in their senior years at secondary school. Some examples are as follows:

> We were all very close to .... Most of the boys played hockey .... We worshipped art and hockey .... On Saturday afternoons after we had finished hockey we'd get the key to the art room .... We would let ourselves into the art room and spend the whole afternoon there. We had access whenever we wanted and we could stay as late as we liked.
>
> When we were in Matric. we spent our whole May and September holidays - six o'clock in the morning we went down and we'd stay there until midnight. We would spend the whole day in the art room working.

Six of the subjects mentioned teachers of other disciplines who were significant influences on their development as artists. Usually it was an appreciation of art and culture or perhaps an appreciation of the natural environment which encouraged the subject to take a more open and considered view of the world.

> I can think of two people who were major influences on me as a very young artist. The first was a high school teacher who recognised that I had a talent and so encouraged me to pursue art and encouraged me to look a lot at prints in books and secondly my history teacher who encouraged me in history and helped me to develop a love of history. They were the two people, both teachers at secondary school, who in retrospect were strong influences on my development.
>
> I liked the art teachers - they were good people I thought and I liked them very much. It is amazing how much that interpersonal sort of stuff between yourself and teachers influences your performance. I really liked my Biology teacher too - and that was an opportunity to draw because we did a lot of drawing on Biology.
>
> Mrs ... decorated her home with paintings. I suppose that this was the only home I went into which would have had on the walls original works of art. She was a big influence on my life.

Category q: Social contacts at school

This category refers to those instances where subjects referred to close friendships that were formed in a school setting based on a common interest in making art. Eighteen of the participants recalled the significance of at least one social contact while at secondary school. In most cases the contacts were made at school. Often, it was not until secondary school that some of the subjects actually made contact with other individuals who were as involved in art making to the same extent as themselves.

> I remember talking to some friends who were obviously enjoying art as well. It was an enjoyable subject for them too. We used get into the art room and work at lunch times. We were really trying to perform in that area. There was a sort of a connection, like a peer group almost like a group of associates for whom it was a stronger concern than maybe other subjects would have been.
>
> I remember also another kid that used to draw a lot and we used to sit next to each other in school and I'd just draw while all the classes were on and we used to get into trouble but we just wanted to do it and it wasn't available at the school.
>
> My best friend was involved in art making too. Actually, quite a few of my friends were involved. We used to do art as a subject at high school. I loved it, really loved it. That was when I got my first taste, I suppose, of Impressionists, which was through the history component of the course.
>
> I had friends at high school. One I picked was a good artist but she left and went to a private school. Then I met ... in an art class. We became very close friends. We spent all our time in the art room. Pretty soon we got access to the art room at lunch time and we just lived there. So we could do things at lunch time as well. There were just the two of us.
>
> I started to find one or two friends with similar interests. I have got a friend who is still a painter who I met at high school. We would go out and paint on the week-ends together. But I was finding it difficult to find the fodder to paint at school so I was going out and drawing landscapes on the week-ends. He came with me. He now has exhibitions and still paints.

Ten of the participants indicated that the social contacts initiated at school led to extended friendships outside the school setting, and in some instances, the friendships have been on-going into adulthood. Some examples are as follows:

> There was a group of us who were really keen on art and we were really keen on music. We sang, took part in a lot of madrigals and group singing and things like that. This friendship that I had with the other girls existed outside the school setting as well.
>
> The first one in my peer group who was like-minded was at about second year high school when we got to know each other. I still maintain friendship with him. He's in the music business in London. He went to art school but moved into the music area. I stuck with art. Another friend became an architect . These were friends from about fourteen and fifteen. There were about five of us who were close friends and interested and gifted in art.
>
> I made a friend called Winston. He is now an architect. We discovered we both liked drawing. And so because the school didn't offer art lessons, our parents - even though my mother wasn't very rich - we went and had private lessons from a couple of art teachers.

Ten of the participants referred to relationships which developed between the peer group and an art teacher usually involving the teacher having social contact with the subjects outside the school setting. Often, such a teacher also encouraged the participants to use the art room during non-class time such as during the lunch hour, at weekends and during school holidays. Some examples of such a relationship are as follows:

> My teacher would invite the group of boys to his house on a Friday night and Saturday morning to do extra work. We had extra tuition and then we would go and have a meal with the art teacher and his wife. This encouragement had an important effect on my life.
>
> We were all part of a sort of club organised by the art teacher. We went to his house. We were all supportive of each other. There was a very healthy attitude to music, art, drama, reading of poetry and that range of subjects.
>
> We were very close friends in the group. We did every thing together. We were interested in art together and we worked together. [The teacher] was part of that too. He was a major influence on me. There was a strong desire to be with my mates. ... was a very close friend. ... in his own quiet way was an influence too .

Category r: Project work

This category refers to the art work produced in curriculum areas other than visual arts which the subjects reported as being important. A significant aspect

of school for sixteen of the thirty four subjects was illustrating work produced in other curriculum areas such as history, geography, poetry and nature study. Some examples are as follows:

> We did a great deal of nature study. We always did that. We would go out for walks at least once a week as a group and really look at everything we saw. We knew all the trees. We knew their yearly cycle and all the birds.
>
> In the senior group I sketched some leaves, otherwise it was purely observation and talk. There were lots of things to look at in the class room such as flowers, frog spawn, stones and other objects we collected on our walks. We would draw them but we never had paints.
>
> You had a pastel book which we did nature study drawings in for nature study so we'd go out and draw some leaves. I don't remember having to really make art at primary school, ever. We had pastel books, a few drawings but mostly to do with nature study or social studies or geography.
>
> We did nature study. We had a special nature study book with alternate blank and ruled pages. We went outside and collected leaves and seeds and insects. We had to write down what we had seen and we were allowed to make little drawings of what we had observed.
>
> We had a nature study book with one page blank and one page ruled. We would go outside and find interesting leaves and draw them and make comments on the ruled page.

While this was a normal part of primary school work, at secondary school, social studies projects and mapping were favoured activities and some examples of information provided by the subjects are as follows:

> At school I used to like doing maps. Maps of Australia and Tasmania. I used to like putting the blue water around and I can remember once I developed a technique of putting two or three layers of different shades of blue around.
>
> In geography we were able to do maps. I loved drawing maps. I was crash-hot on maps. I could draw a map of Australia, no problems at all .... I always coloured in the sea around the map. It had to be the right blue. My teacher said, 'Oh! You're a very good drawer.'
>
> We used to do maps as well, and I really liked mapping. I could draw a map quite well from memory, not tracing it. I forgot to take my Atlas home, I'd get bad marks maybe 7 out of 10 instead of 9 out of 10 but I could draw fairly well using my visual memory. In the little Atlases that we had, there were little teeny pictures of things like: where coal is mined at Yallourn and there would be a picture of an open cut mine with tractors and trucks down there, or bananas at Coffs Harbour all that sort of produce area maps and I remember copying a picture from one of these Atlases.

> The trucks working and I thought a lot about it since and it was oil pastels again and I had actually drawn the picture with black first so I had gone around the outline and copied it with black and then I'd used really bright colours on the truck - colours like yellow, white and what have you and when it was finished I remember my teacher saying, 'Oh! That's fantastic. It's a great drawing you know!' And I've thought about it since and I thought: it probably looked a bit dirty and 'grotty' like the quarry because of the black around the outline and the other colours mixing in. You don't have the sort of control where if you want a straight black line you can have a straight black line.
>
> I've always liked art. At primary school I can remember colouring in pictures including drawing maps of Australia and putting furry blue around the edge of Australia, colouring the yellow in the middle and stuff like that ... and drawing pictures of Burke and Wills and Blaxland, Wentworth and Lawson and Sturt and so forth and drawing those.

Eight participants commented that apart from art, their favourite subjects were those that encouraged and rewarded students who produced colourful illustrations. For example:

> I took biology because I was more interested in geology and biology. But again I'm sure those choices were because you had to have drawings in the books. I just went for the things where you had a nice book you could draw in. And geography - you know - they were all choices that I finally made which had the related drawing aspect. Because I was at a hostel and we had to do home work any one who had to have a drawing in their social studies or science books I did their drawings and they did my maths and French. I'm sure that the teachers knew because all the books were the same because they were done by me. It gave me a lot of practice and I enjoyed doing it.
>
> When I first went to school I did a lot of art projects. They were all part of story telling, poetry, music and things like that. Art was an extension of those activities rather than a discipline in its own right.
>
> I used fine line pens. In science classes, I would regularly get 10 out of 10 for the illustration of the experiment and absolutely nothing for the experiment, so I'd usually team with somebody and do all the drawings and they'd be Gothic masterpieces and yet the write up was a catastrophe. Anything that involved drawing - and I'd illustrate all the margins in my books and get into trouble for that.

Generally, the illustrations required by the other curriculum areas were fine pencil drawings. The use of coloured pencils and more recently, fibre tipped pens, were particularly suitable for the skills of the art-focussed individuals.

> Later on in primary school I think my drawing got better and I can remember being very skilled at doing illustrations for project work. We used to do our projects not in

> books but on large sheets. So we were issued with the large sheets. And I had always thought that was a strong link with my later painting when I got on to art school was the layout and design, a relationship of blocks and texts to areas of imagery on these project sheets that we used to do. That was when I think I really started to get a lot of reinforcement, I think in a public sense, about my drawing. The school inspectors used to come around to the schools and I remember the fuss, the day the inspectors were coming and everything had to be tip top. I don't think I was very good academically or any other areas but the illustrations that I used to do in my books were really highly regarded. So they used to haul me up to the front sitting in the front row and open all of my books to the pages where I had done the illustrations. And they always used to make an issue of not just running the inspector past me but hauling him up to have a look at my drawings. A feature was made of my drawings and I remember that being a really impression like I was being pinpointed as having the skills in illustration.
>
> We generally used coloured pencils for the illustrations. Sometimes we used those coloured crayons. But I don't remember a great deal about using paint for illustrative work. There were sets of coloured pencils that were issued to us any time we did our drawing.

At secondary school, the subjects who were exposed to art history as part of the visual art studies, recalled having to reproduce detailed drawings of historically significant architecture and sculpture. Sometimes the original images were quite small black and white photographs, while in other instances, the art teachers would prepare coloured interpretations in chalk on the chalk board which the students were then required to copy into their note books.

For more extensive project work, some of the subjects used paints and crayons for larger scale work to impress the teacher and peers. Some examples of responses by the subjects are as follows:

> I think book work was much more important then than it is now. I mean you would be given a little book that you worked in all the way through the year and it was a precious object. We had one, it was cut quite small, it was about six inches by four inches and the teacher had put it together with one page for writing and a blank page for picture and it was a Bible story book and you would have painstakingly written something about Joseph and his coat of many colours. I assume once a week, when it might have been once a month or once a fortnight, I can't remember. And then you would do your picture on the other side. I can remember doing that and you were so proud of these books because they lasted for such ages and you had to do them so beautifully. And I think that's, it is a shame nowadays that so much art work is done on scraps of paper because, I am jumping ahead a bit now. Even in Junior school our books would all be put in to be marked for the school fair and you would open it at your very best page and you get an A or B or a C, and it would go towards

house points. And I think the pride that we had in those books was something really worthwhile. We had a very good teacher in Grade 4. She must have been to England on a trip and she thought she would take us as her class on a trip to England. I will never forget that because it went all year and we started off, we all made our own passports and we pasted in our photos that were brought from home. And everything was so beautifully done and she had a big diagram of the ship and we could each select our own cabins and we had to write which cabin we were in. As the voyage progressed, we learned about each place we stopped at. So when we stopped in Sri Lanka we would do a page about Sri Lanka, and it was all meant to be so carefully done. I loved doing that and then finally we reached London, the epitome of going to anywhere and we did our London pictures. She was a good teacher because I remember all about it and I enjoyed it so much. I kept that book for years and years.

I can remember in first year, we did French language and I was terrible at that. I just didn't think it was important for me to try. I remember my report card for that summer being U, U, D, U, D, D, A, D, D, U and the A standing out like a beacon. I remember that was because we had to do an illustrated project about aspects of Paris and I just 'went to town' with the drawing. My oral French was just dreadful but I was given a chance to do a visual project and I sort of scored the top mark.

Category s : The school art room

This category refers to the importance which the art room played in the daily lives of a significant number of the subjects. Twenty two of the thirty four participants reported that they had considered the art room as a kind of oasis during their years at secondary school. Several participants described their secondary school art room as a refuge. This attitude could be linked to the fact that they perceived themselves as outsiders and that they preferred to make art rather than join in the other lunchtime activities. In the art room they felt relaxed and safe. The subjects enjoyed being surrounded with art materials and reproductions of historical examples of art work which were often reproduced as posters and prints as well as illustrations in books.

The teacher would give us access to the art room so that we could use the facilities during the lunch break as well as before school.

When I moved to secondary school from my primary school there was a marked change. Art was a particular area of study with at least one special art teacher. There was an art room and the art room became a refuge for me. It was somewhere I belonged, but I didn't belong anywhere else in the school.

My secondary school stressed sciences, mathematics and sports. Those subjects seemed to be the most important. The senior teachers talked about having art as a priority and they prided themselves that ... was the art master - he had left just before I got there and then his successor was ... who lectures at ... and he also writes books - he was a real character and I think that it was as much that he was a real character as anything else that made that room a delight to be in. I realise now that it's one of the things that an art teacher can project - being a character. It can get you out of all sorts of other responsibilities. His art room was definitely a refuge.

I couldn't get to the art room quickly enough. There was a sharing with my friends, who were also involved in art making, about ideas and techniques. There was a sort of camaraderie so they became my friends in the school yard as well. After a while there was a certain status attached to being the best artist or the best drawer in the school. I'd be asked to do illustrations on the chalkboard. I had status as a good artist.

We would let ourselves into the art room and spend the whole afternoon there. We had access when ever we wanted and our teacher would allow us to stay as late as we liked. Very often there'd be no teachers left at school when we left .... We would spend the whole day in the art room working.

We were allowed to use the art rooms at lunch time. Yeah, there was a little bit of a club, not always, it wasn't always. But it happened. If you wanted to finish your painting you could stay in there and do it. And there were older kids and younger kids and, whoever wanted to be there could work there.

Art class was all I lived for in a way. I immediately found a niche that satisfied me and I was good at it and it was the only thing I had been good at because of the learning problem which was starting to disappear ... I spent every lunch hour in the art room.

I used to spend whole lunch hours in the art room because we could go in any time and do what you wanted to do. There was always a few of us there - the keenies - and the group changed as I went from year to year, but I spent most of my time there. Anywhere else I was insignificant, but in the art room I was the best. In later years I made the softball team at one stage, so I did do other things so I didn't exclude everything. I wasn't allowed to do art on the activities afternoon because I was always there any way so I was excluded so I joined the stamp club and I just loved it that activity too because it was just like the scrap books which was an ongoing interest of mine.

The art room was always a place that you could go and spend more time. If I had a free lesson or if I had any spare time, I'd always go to the art room to do something. I remember floundering around a lot. I remember spending a lot of time going through graphics magazines and design magazines.

We spent all our time in the art room. Pretty soon we got access to the art room at lunch time and we just lived there. So we could do things at lunch time as well. There were just the two of us. There were other people in the mob but the others didn't come into the art room at lunch time.

Category t : Special art classes

This category refers to subjects attending art classes outside the regular school classroom. Fourteen of the subjects reported having had access to special art classes. In some cases, the classes were ad hoc and usually arranged by a parent.

> We used to have a special art lesson now and then at home. My mother had a close friend who was a painter ... we would spread newspapers on the table when she came and she'd give us a class .... I remember loving it ... the sun coming through the window and the brushes and the paints ... she was an enthusiast.

> I used to do special classes in drawing Wednesday afternoon and Saturday afternoon. I started these [special] classes when I was in Grade 3. I wanted to do oil painting but I wasn't allowed - they said I was too young.

Ten of the subjects who lived in a city environment were enrolled in regular Saturday morning classes. These classes were usually taken by teachers at a Technical College for children who had been identified by their regular classroom teachers as having particular abilities in drawing and painting. Some examples are as follows:

> My mother was always a great go getter for going to classes. In fact I think I spent most of my life in classes doing one thing and another. In Grade 3 I went to the Saturday morning classes and I was there for six years. We were like a real club there; in fact they brought in a rule after you'd been there six years you had to leave to make way for others because of the waiting list. I used to enjoy the art classes at Tech. very much because I kept going for six years. I remember the time when clay was introduced; in fact I could take you to the very spot in the building where it was introduced. I could show you the room and where I was in the room. It was the brown clay, probably from ... and I loved it I thought it was wonderful. I don't know that I had modelled anything before. I would have been in about Grade 5 I think and this was the first time I had come across clay and I can see now what I modelled. I modelled a swan with its back open so that you could put things in there and I recall that I was shocked to find at the end of the lesson things were returned to the bin. I remember thinking that that was not good! To this day I don't think it was good either! I don't recall that anything was actually taught about how to use the clay. The role was that they were collecting some extra money for Saturday morning teaching.

> ... and then the other thing that I did out of school on a Saturday morning for several years which would have spanned upper primary and lower secondary was going to an art class which was held in ... College, this is in ... , which was a teacher training college and obviously it was a student teaching business. But some of the people

who were running it were very significant people in the sort of circle in new art movement, post-war, pre-war, just pre-war and into the war years in ... and one of them was ... who was quite well known and another one was called .... But they were very encouraging and exposed me to all sorts of new materials, different colours of paper to work on and really opened my eyes in lots of ways to what art could be, so I owe an immense debt of gratitude to those classes that I had, which was really great. So that was something which provided a great deal of interest to me and a great deal of encouragement and a great deal of broadening my experiences in art. I would do all sorts of things that you want children to do - big paper, big brushes, how to paint and charcoal and all those sorts of messy things. So that was something I have looked back with great gratitude, those people who provided such time and space and opportunity. I would have gone there probably at about the age of ten I suppose. I don't know how I came to be at the special art classes. It could have been initiated by the school in that they could have well picked me out of as being somebody with potential, because I am sure I had already got that, you know, I had created that sort of impression amongst teachers by my keenness as much as by what I produced, I am not sure about that. So it well could have been suggested because in fact the primary school I attended was in the same part of town as this college. I was able to walk over every Saturday, so it was like a feeder school, I think it could have come through the school. But my parents certainly would have encouraged that as well.

I went to special Saturday morning classes at ... this was when I was about eleven. We did drawing and painting - art was my favourite subject.

My teacher said to me, 'You should be going to Saturday morning classes'. I must have told Dad when I went home and he said, 'Ask her about them', but I didn't ask anybody about anything so I think some time later, he must have asked her about it and he organised for me to go to the Saturday morning classes and that was wonderful! The classes were held in the art department of the ... in amongst the oil paintings and the smell of the oil paints. I was only about seven or eight at this stage. They had newsprint, tobacco tins with thick jelly-like paint - powder paint mixed with size, big brushes, and there was a list of subjects written up on the board and I would whip up great big paintings and at the end of every morning, they would pick out the best ones and put them on the board and I always had a picture on the board. There was no instruction given. I kept going to these classes for years on Saturday mornings. It was always painting - nothing else except for charcoal. I loved it! ... I knew at that early age that I was dealing with actual artists there.

... he came in on a Saturday morning and took those who were interested [in art]. Now that was really great, it was very stimulating.

In four other instances, subjects were enrolled in shorter courses which were offered as a school holiday activity or as a series of early evening classes.

When I was eleven or twelve, I went to a pottery course. I was also sent to evening classes. The teacher was a painter. My brother and I were sent and we were the only children. My mother had this drive to educate her children and I suppose to give them a very good cultural upbringing as a reaction to her own home environment which was very working class. And so I always thought the things I did for my mother not always for myself. It was fun going out in the evenings and I was quite

> flattered to be treated like an adult ... at Christmas time I would go to workshops where we did enamelling, basket weaving, jewellery, mosaics, stained glass - almost every thing you could imagine. I also recall going on a holiday activity with a potter: we did pit firings.
>
> My parents sent me to the local art school in the summer holidays to do some kind of course that was on .... I became aware of the paintings and the other art that was there [at the art school] and that created an interest in art for me and I used to go there often just to look at some of the art. The course mainly involved painting and drawing. All of a sudden I was meeting kids from other parts of the city who previously I wouldn't have met. They were all interested in art making too.

Category u : Prizes and awards

This category refers to the recognition received through the award of prizes and awards for art works. Eleven of the thirty four subjects remembered winning prizes and being given awards of some kind for their art work. In six instances, they had entered competitions after being prompted by a parent or a teacher. For example:

> I was encouraged to enter every drawing award as an infant and I must admit, because it [art] was around me all the time, I took it for granted. I actually won an art prize, I think when I was in Grade 3. I won the ... Art prize for children of my age group. I had to do two paintings for it. It was in different categories - one was a rural scene and one that I thought I might have a chance at winning a prize in that particular category and it was the first painting I did and I laboriously spent ages doing it - like weeks and weeks and it was quite a large painting, and I was really surprised because mum made me enter the second one. I didn't want to do it; it wasn't a subject matter I really liked. But Mum was a very forceful woman and actually made me stay in and not go to the beach and not play with my friends but to have a go and finish the second one. Because I didn't want to do it, I raced through it and then when they were announced in the series and I had chosen the particular one that I'd wanted to go for, and when my name wasn't announced for that one I just ignored it and I didn't even know that I'd won the other prize which was equal to the first but it was just that I hated the painting. I was forced to do it, and I'd raced through it and just thrown it in to say, 'There, I've finished!' And then I'd won the ... Prize with it and that at the time didn't touch me very much but it did in retrospect.

In five cases however, the subjects were highly self-motivated and quite independently prepared work for competitions and entered in the hope of gaining recognition for their work as well as the hope of winning a prize. Some typical examples of this category are:

> I took part in a competition and won it. I can remember the picture I made because I stuck my own hair on it. It was a figure and it was sort of a collage painting and I remember putting the hair on the figure - cutting a piece of my own hair and putting that on. I think it was something to do with the week of the elderly people or something like that.

> I entered competitions for various things. I remember winning a couple of prizes at primary school - one for the *Gould League for Birds*. I won the State prize one year. I also won another prize. I did a painting of the [Sydney] Harbour Bridge.

Phideas, who presented the art segment as part of the popular children's program, The Argonauts, on the Australian Broadcasting Commission radio, provided regular motivation for children who wished to receive recognition and rewards for their art work. Certificates were awarded weekly for work submitted to Phideas. As well, the names of the winners were read out on the radio. Following are some examples provided by subjects reporting the influence of Phideas:

> I used to listen to Phideas. I would send in my pictures but only those that I did at school, but I never sent the stuff I did at home. I received some purple certificates and I used to write letters [to Phideas].

Colouring competitions are regularly organised by various businesses and companies. Seven of the subjects, feeling confident with their ability to colour neatly, entered such competitions. For example:

> I used to have quite a bit of success in colouring competitions which I loved. I once won a wireless - that was a great triumph ... and I won tickets to something called *The Tintookies* and I won tickets to *Paint Your Wagon* at the Theatre .... They used to have a thing called the ... art competition and once I had a painting in it I might have been highly commended but I can remember going up there and it was on an easel and I was so pleased with it and that was an oil painting. Probably about three foot

> by two foot of a woman sitting at a table in a cafe with a cup of coffee. She was rather a plump sort of lady. And I was awfully pleased with that painting.
>
> During my last year at school we had a fair and we had a fence painting competition around the new tennis court. Boards we put up on the fence and people were charged fifty cents to enter. I did the rip-offs from my teacher and I won some money. Then there was an auction of the rest of the work and I made about sixty dollars on the day. I couldn't believe it. It was as much the money but it was like people had let me step out of the closet and I was there and they were saying, 'Oh! I didn't know she could do that!' and it was like I had been at high school and I'd been at primary school and I'd mucked around with all this stuff for a long time and all of a sudden I was getting some sort of accolade for it. I was really happy about it. I thought it was great.

Generally, subjects indicated that work for competitions was done at home but there were some exceptions, depending on the teacher. Book Week was a regular competition which was usually supported by the school because of the emphasis on encouraging the use of libraries. For example:

> We were not really allowed to draw things about our own experiences. Only when Book Week was introduced and I used to love books especially having them read to me. I was always being read to. We were read a story for Book Week and then the teacher said that we could make an illustration of the story and then send them off. I won the Book Week competition. I can remember that it was a man ploughing a paddock with a horse. I can't remember the story, but I can I can remember the picture quite vividly.
>
> At school in Grade 5 on Friday afternoon we'd have drawing one week and handcraft the other week. I did tapestry - I got interested in doing stitchery tapestry things and I used to quite like those and rug hooking and I did this cushion using a zig-zag motif on a sugar bag and it looked fantastic - it must have been the colours I did it in - yellow and orange and brown - and it was decided that I should enter this cushion in the show and somehow my mother was distressed to find out that it had been entered in the adult section and she went to the show office to complain that I was only nine and they said it doesn't matter Madam whether he's nine or ninety, he's entered in the adult section and that's where he stays. So poor little ... had to compete against the ninety year-olds as well. So on the day of the show we went out to see if my cushion had been included in the adult display and sure enough they'd put it in the glass cabinet - there it was with a blue ticket on it - First Prize!
>
> I will show you an example of something that I won a prize for. Here it is, a miserable little black and white photograph about one inch by one and a half! And that is what the competition was, to copy that. It is amazing! I was actually thirteen then ... and I just liked competitions and I liked winning prizes! And here we have this postage stamp really, it is a postage stamp-size head of somebody who was a pioneer in the Co-operative Wholesale Society movement and a grand book prize was to be given for the best drawing copied from this photograph. And I won the prize and so I must have done reasonably well.

In this chapter, data selected from the thirty four interviews has been selected and presented under the six major groupings of inherent ability, familial influences, access to imagery, technical knowledge, socialisation and school influences. Twenty one categories were generated from the raw interviews using NUD.IST. Excerpts from the interviews have been presented by the researcher to support the twenty one categories.

CHAPTER 5

Discussion of results, conclusions and recommendations

Introduction

Thirty four artists residing in Tasmania were interviewed with the purpose of investigating the childhood experiences of contemporary, recognised visual artists in order to document and identify formative influences which nurtured their interest in visual art through childhood into mature professional development.

The sample of subjects used for the research consisted of artists practising in a broad range of art forms, namely, painting, textiles, ceramics, illustration, sculpture and print making. As well, the sample contained equal numbers of males and females.

The research question for the study was:
What are the outcomes of interaction between a child's environment and a child's artistic propensity?

The assumptions were:

Assumption 1

Artistic abilities are inherent in certain individuals.

Sub-assumption 1.1

People with artistic abilities display a trait of perseverance.

Sub-assumption 1.2

Artistic abilities are enhanced through access to art techniques.

Assumption 2

Environmental influences nurture artistic propensity.

Sub-assumption 2.1

Childhood experiences nurture inherent artistic ability

Sub-assumption 2.2

The motivation to become an artist may be nurtured by

a. People within a child's familial environment (including parents, grandparents and other relatives).

b. A child's educational environment.

   i. Classroom teachers.

   ii. Specialist teachers.

c. Contact with art forms outside the school setting.

d. The degree of socialisation.

Assumption 3

The development of artistic propensity is an outcome of interaction between artistic ability and environmental influences.

The discussion of the results of the data analysis in relation to the groups and categories (see Chapter 4), which were developed from the above assumptions, can be viewed as major conclusions of the study.

Discussion of results

Inherent ability

The data derived from interviewing thirty four artists indicated that from an early age there was an inherent 'streak' which motivated these individuals to produce art. All subjects viewed themselves as possessing an inherent, passionate interest and skill in making art, which began during early childhood. Many of the subjects, when interviewed, indicated that there was always a time when they wanted to make art. This result reflects research studies (Bockris, 1990; Dutton, 1992; Hetherington, 1963) concerning historically significant artists, which showed that they also identified a desire to pursue art from an early age.

Perseverance

The desire to make art images was so strong that most subjects referred to instances, during their childhood and adolescence, when they had displayed perseverance to produce art works, even when they had been discouraged by others including a parent, a sibling or a peer.

Many of the subjects preferred to make art rather than participate in activities pursued by other children in their social group. The decision to be independent in their art making activities sometimes brought them into direct conflict with their peers, who did not appreciate their strong inner drive to make art. It required perseverance on the part of the subjects to follow their urge to isolate themselves and make art, rather than please their peers by participating in the more accepted social activities and games.

Subjects in this study reported that their parents expected them to be outdoors playing. However, subjects stated that they preferred to be indoors drawing, painting or reading and they reported that they developed particular strategies to enable themselves to devote time to engaging in art activities.

Coupled with an inherent artistic ability, results of this study indicate that there was a drive or perseverance common to all subjects to pursue their interest in art and to master the use of art techniques, whether it be the mixing of a particular colour or the drawing of a specific feature of an object. Subjects persevered in an attempt to achieve visualised outcomes whilst often having to struggle to overcome very difficult technical problems in the process. To achieve a special effect, which had been noted in the reproduction of an example of adult art or to produce images which appeared realistic, relied on the subject applying careful attention and hard work.

The identification of gifted and talented children is based on the widely held assumption that characteristics of talent can be identified by others and that these children can be helped to further their abilities. Though self identification may be utilised, generally the identification of gifted and talented children is undertaken through observation and testing. Results of this study seem to show that individuals identify artistic talent and ability for themselves, that the identification occurs early in life and that it is accompanied by strong commitment and perseverance. Howe & Sloboda (1991a) found, in their study

of the early lives of musicians, that there is a close correlation between the ability of a child in a particular area such as music and the idea that these abilities can be inherited. The responses of subjects interviewed by Dutton (1992) indicated a sense of commitment to art making and a willingness to persevere with art making even in difficult circumstances. Characteristics of perseverance and commitment as well as self appraisal need to be acknowledged as important for the identification of gifted and talented children in visual arts

Familial factors

Results of this study show that the development of artistic propensity is an outcome of interaction between artistic ability and environmental influences. People with artistic ability:

1. Need the support of family members;
2. Seek stimulus from the natural environment;
3. Require access to art resources including visual images, and
4. Value and welcome periods of isolation and opportunities to engage in art making activities.

As part of the selection process for children talented in art, subjects in this study reported the impact of practices at home. The motivation to become an artist seemed to be nurtured by people within a child's familial environment. From the data gathered for this research, it appears that the intense interest in art making is observed and noted by family members and/or the parents of the child and usually supported and encouraged by them.

In instances where neither parents nor close relatives made art, the keen interest in activities such as drawing and painting, exhibited by the subject, had

generally been encouraged by family members, even though the desire to engage in such activity was not well understood by the adults.

In many instances, parents of the subjects recognised a special interest or ability exhibited by the subjects and they supported their child by providing art materials and simple equipment such as brushes, a box of paints or an easel.

Support from family members is significant for children with artistic talent to realise their potential. Findings of the study show that family members employed a variety of strategies to support the subject's interest in art. These strategies included the supply of books about artists and art techniques; encouragement to enter art competitions; financial support to enable the child to attend art workshops during school holidays; granting permission and providing financial support to attend Saturday morning art classes and the provision of technical support.

As well, the home environment was important for the subjects in the acquisition of art techniques and skill, rather than the school. Technical assistance was provided by a parent and/or grandparent for one third of the subjects. Typical of the kind of technical information supplied by a parent or a grandparent were strategies required to draw a human figure or a portrait using 'appropriate' proportions, along with the use of perspective to ensure that buildings looked 'right' or that fence posts appeared upright in a landscape drawing.

It is interesting to note that similar characteristics were also identified in the biographical and autobiographical studies of well-known artists. Spencer (1991) made particular reference to the influence of the illustrations in the story books read to him by his father; Auguste Renoir's encouragement in his early efforts of drawing by his father is documented by Jean Renoir (1962); Bockris (1990) in his study of the artistic development of Warhol, points out the significant

impact of the support and encouragement provided by Warhol's mother for her son's early art making.

The environment

The childhood environment experienced by subjects was identified as a very significant influence by thirty two of the thirty four subjects. The natural environment associated with the home, and activities such as bushwalking, was specifically mentioned by a majority of the subjects and features such as trees, the sea, beaches, mud, gardens, earth, rocks, insects, animals and fish were important aspects of their sensory experiences. Some of this interest was manifested in the preoccupation with collecting objects, but much of the interest was reported as discriminatory observation of visual-sensory stimulus in the environment. Collecting and categorising were often important activities undertaken by subjects which relied on keen observational skills and heightened visual discrimination.

In early childhood education, exploration of the environment through play is considered to be an essential aspect of learning. The literature on creativity (Getzels and Jackson, 1962) focuses on the importance of play and the imagination, in promoting the development of creativity in children. Many art class rooms engage children in imaginative activities, but these activities tend to be teacher directed rather than student generated.

Religious imagery

The impact of religious imagery was a direct result of the religious beliefs and practices of those subjects who were raised in the Christian faith. This would seem to be an expected outcome for individuals with an intense interest in images, who find themselves surrounded by religious art works including paintings, sculptures, stained glass and murals featuring religious events. A frequent source of visual imagery arose from the impact of religious images

and was closely linked to religious belief and practice and the influence of the family.

Visual discrimination

It is important to consider that the kind of language used by the subjects, when describing their childhood experiences for this study, is that which has been refined by them over many years as practising artists. One would expect artists to be in command of visually descriptive language. However, subjects in the study had retained specific memories of their childhood sensory experiences and it was significant that they could remember and describe in great detail their early sensory experiences. Several subjects were able to describe details such as smells and textures which had been part of their early childhood experiences. A high level of sensory discrimination was reflected in the description of the things that subjects collected and classifications they made of objects.

Based on the teaching experience of the researcher, the detailed descriptions provided by the subjects of their childhood experiences indicated a much more complex description of sensory experience than one would expect from children in a regular classroom. An on-going difficulty, which teachers have to deal with, is the training of children to be visually discriminating. Visual discrimination should be a vital part of learning, as part of the art curriculum, along with drawing, painting and clay work. This is an area worthy of further examination.

Although the subjects in this study were artistically talented, there are implications for the need to train children to be visually discriminating and to raise sensory awareness as part of regular art learning in schools.

Technical knowledge and access to imagery

The subjects had a strong, on-going desire to acquire skills and knowledge about a wide range of art materials and processes. As young children, when the main focus for most subjects had been drawing, the interest tended to focus on the skill of drawing particular objects so that they looked correct or 'realistic'. The solutions to technical problems were sought from resources available, or obtainable from sources such as print material art galleries and adults. A self-directed problem solving approach was used which relied heavily on the availability of resources. The subjects appeared to seek challenges and they liked to solve technical problems.

Access to art works or visual images appear to stimulate the development of artistic ability. A common source of technical information was books. Most subjects remembered using books containing visual information relating to the drawing and painting of subject matter, such as portraits, the human figure, animals and landscapes as points of reference for technical knowledge regarding the making of visual images. The quest for technical knowledge often related to the sequence involved in a particular process or the desire to know how to achieve particular effects with various media. Books and journals about art making were standard sources of such technical information.

Sources of imagery for subject matter were derived from picture books, magazines, comics, movies and television. Images used to promote popular rock bands and recording artists were influential for many subjects, particularly the males. Toys, which were often associated with comics or movies, such as Disney characters and the *Star Wars* movies, were also used by some subjects to provide specific information for drawing their favourite topics.

Some subjects had been taken to exhibitions, galleries and museums by their parents. In those instances, where subjects had spent their childhood in an urban environment, the visits had often been quite regular; while the subjects who had spent their childhood in a rural setting rarely had access to exhibitions of any kind. It was only on such visits that subjects had been able to gain an understanding of particular characteristics of art works including the texture of some oil paintings and the actual size and scale of the works.

Contemporary art education policy has tended to veer away from teaching skills and focussed more on self expression. Results of this study indicate a need to reassess this trend and to investigate more carefully the impact of art instruction, and the range of resources provided.

Copying

Copying was an activity commonly employed by most of the subjects at some stage during their childhood. In particular, copying occurred during upper primary and early secondary years. The researcher identified a reticent attitude exhibited by many of the subjects when the issue of copying was raised. They responded as though it was not quite respectable to have copied, let alone admit to it. In most instances, the gathering of visual ideas through copying was an activity carried out at home but rarely in the school art room, perhaps due to the attitude of teachers to copying. This may reflect the negative views many art educators still retain about the place of copying and its value in acquiring knowledge about subject matter or learning about specific art techniques. However, the use of copying by artists, in many cultures and over many centuries, is now well documented (Gardner, 1980), (Wilson & Wilson, 1982), and (Duncum, 1985a).

Since the 1950s, copying, as a means of solving technical problems, has been a contentious issue in art education literature. The impact of popular imagery on children and the use of copying has featured in the research of Wilson &

Wilson (1977) as well as Duncum (1987). The information provided by the subjects participating in this study generally supports research findings concerning the importance of copying images from popular sources. For those students for whom copying was an important activity, the resultant art works provided a source of praise by adults in their home environment, as well as by their peers, who admired the technical skills exhibited by the subject. It is important to note that a small number of the subjects reported that they had no memory of having copied images from popular cultural sources. However, most subjects appeared to be visual 'scavengers' in that they borrowed and used images from a variety of sources in the environment, whether through the observation of the natural and man-made world or via the visual work of other artists.

Results of the study suggest that copying has a place in an art program and should be promoted as a method of acquiring drawing skills. Wilson, Hurwitz & Wilson (1987) suggest that students develop their drawing skills both by studying how other artists work and from their own experimentation. Duncum's research (1985a) was drawn from subjects who were artists and who could be considered exceptional. It is not clear whether copying is a technique appropriate only to the talented in art or whether it could be a useful technique to a wide range of children.

Perhaps the broader need of acquiring technical skills is more relevant, with copying being but one aspect or way of acquiring technical knowledge. Wilson, Hurwitz & Wilson (1987) suggest that children require a range of drawing activities, including the opportunity to copy from the art work of others. Children may need more instruction generally in technique and, if so, educators may need to revise attitudes and acknowledge greater importance for children to acquire art skills and art techniques. There is a need for more research in the area concerning technical skills as well as the effects of copying as a technique with children in regular classrooms.

Socialisation

The degree of socialisation may act as a motivating force for a person to become an artist. The results of this study support previous research findings of Gallagher (1975) and Barron (1972) which indicate that artistic people tend to be anti-social and like to work alone. Research concerning the characteristics of people identified as creative suggest that these people prefer their own space to work alone (Getzels & Jackson, 1962).

Isolation

The degree of isolation experienced by most subjects in the study was an unexpected finding. It seems that people with artistic ability have their ability stimulated when they experience isolation and/or illness. It may be that for artistic ability to develop, there needs to be a degree of isolation provided, in order for such people to exercise perseverance and imagination without distraction. This finding could be important for research concerning gifted and talented students, with regard to work practice and/or teaching strategies. Is this a characteristic of artistic people or is it also a characteristic of people with talent in other areas?

A role model

The search for a role model was an important urge identified by the subjects in this study. This characteristic appears to have been more significant among those individuals who grew up in a non-artistic home environment. Results of this study indicate that there was a strong desire by the subjects to behave in an artistic manner and the identification of a role model was often an ongoing dilemma. Many of the subjects felt that they were 'different', and saw themselves as outsiders, constantly looking for adult models who displayed similar characteristics.

The drive appears to have been to identify an adult who exhibited traits which matched the artistic behaviour of the subject. It seems that it was not necessarily a visual artist who was selected. However the role models were usually people significant in some aspect of the arts including music, dance, drama, film, as well as visual arts.

The identification of a role model helped provide validity for the interest and involvement of the subject in art making. It is possible that the search for a role model was also significant because a significant number of the subjects thought of themselves as being different, or as outsiders, and since they often felt isolated and lonely, from a social perspective, a role model provided them with courage to persevere with their artistic pursuits and interests. Identification with adult role models is a common occurrence in adolescence. Subjects in this study exhibited an expected need for role models and the identification of a career role model congruent with talent, was significant.

School influences

Results of this study indicate that the school had a minor impact in nurturing artistic ability. Subjects who were interviewed for this study indicated that when they began school, even in some cases as early as kindergarten, a teacher identified the child as artistically talented in art. Although a teacher may have identified a subject as artistic, this information was conveyed to parents and the support then emanated from the family environment. In such instances, the teacher communicated the information to parents or family members who were encouraged to seek expert support from out-of-school tuition for the child.

As adolescents, almost all of the subjects indicated that they had been significantly influenced by the work of a specific artist they encountered as part of their school art program. Usually they had become aware of the style and subject matter favoured by artists as a result of studying art history at secondary

school. It was the school which had provided the subjects with access to information about these artists in a formal way. In this sense, the school was more effective in meeting the need for an adult role model.

Results of the study indicate that many of the subjects were recognised by the school community for their artistic skills for which they received praise and recognition. However, in some instances the subjects had been marginalised by the teachers of other curriculum areas where art was used in a purely decorative mode.

Notwithstanding evidence of support provided by some teachers, the results of this study show that overall, the non-school influences provided greatest impact on the artistic development of the subjects.

Results of the study highlighted the importance that special art classes and community art classes played in the growth of artistically talented children.

Conclusions

Findings of this study reveal that individuals who display a keen interest in art making from an early age, are aware of the urge to make images with available materials and begin to do so with a firm single mindedness in early childhood. They seek to acquire technical skills and seek adult role models. Contact with art work and art resources seems to make an impact and was important.

The data revealed that the home environment was a significant source of support for subjects interviewed. Considering education policy and the promotion of gifted and talented programs for students, the case of artistically talented children may not align readily with current policy for other areas of talent and giftedness.

Results of the study indicate that the source of identification of artistic talent came not from the school but from parents and other family members. Further, home environmental influences were responsible for nurturing the inherent talent exhibited by the subjects interviewed for this study. In some cases teachers provided support and encouragement but generally the school was not the major source of influence. Identification as an artist does not seem to rely on an outside institution such as a school, rather, the identification is from the home environment and a 'significant other.'

The need of artistically talented children to work in isolation has significance for school art programs. It would seem more important for children, who are identified as artistically talented, to be placed in out-of-school programs rather than make allowance for those children in a regular school program. Results of the study have significant implications for gifted and talented education policy suggesting that increased attention should be directed towards special and/or out-of-school programs for artistically talented children.

Recommendations for further research

1. Research is needed regarding the effects of art instruction in technique and technical skills for children in regular classrooms and at different age levels.

2. Further research could be undertaken concerning the special influence of media (radio and television) on the art produced by children.

3. Research should be undertaken concerning the use of copying as a strategy for the development of technical skill and knowledge by children in art classes in primary and junior secondary classes.

4. Research could be conducted to consider the effects on children's art from participation in special courses and classes, for example privately organised Saturday morning groups, Adult Education classes, school holiday workshops, gifted and talented camps.

5. Comparative research, in upper primary and early secondary classrooms, involving the impact of copying on children identified as talented and children not identified as talented, should be conducted.

6. Research should be undertaken which examines children's visual discrimination abilities and the effects of training on visual discrimination.

Appendix A

Copy of initial letter for potential subjects

University of Tasmania

Edward Broomhall
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at Launceston

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Fax: (003) 243 048 (W)

22nd July, 1993

Dear

I am currently conducting research for a doctoral thesis entitled 'Formative Influences on Recognised Artists'. The study is an attempt to find out what factors contribute to the development of an artist by interviewing subjects who qualify as experts in their field of art practice such as painters, sculptors, printmakers, photographers, designers in wood, leather, metal and glass, and book illustrators.

The information gathered in the interview will concern your particular experiences of the visual arts - educational and extra-educational, which have led to your high degree of understanding and appreciation of the visual arts. **The questions will focus on your life up to the end of secondary school.** The interviews will be recorded on audiotape to enable precise documentation to be made by the researcher. The audio tapes will be stored in a locked filing cabinet in the School of Education. They will only be available to the investigators and the relevant participants.

I'm writing in the hope that you will consent to be interviewed.

For further details of the research, please contact me at the above address. For your convenience, I have included both my 'phone and fax. contact numbers.

As I am anxious to proceed with this research, would you please communicate your response as soon as convenient. If you are willing to participate, we will need to organise a time and place to undertake the interview, which is mutually convenient.

If you agree to participate, I will forward a copy of the interview schedule so that you will have time to reflect on the questions before the actual interview is recorded on audiotape.

Yours sincerely,

Edward Broomhall
Lecturer in Visual Arts Education

Appendix B

Copy of the follow-up letter for potential subjects

University of Tasmania

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at Launceston

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Launceston, Tas. 7250

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22nd July, 1993

Dear

Thank you for giving your consent to be interviewed as part of my doctoral research, 'Formative Influences on Recognised Artists'.

Please find enclosed a copy of the interview schedule and a statement of informed consent which is required to be completed before the interview is undertaken. The form can be completed on the day of the interview so please retain it until that time. I will contact you in the near future to negotiate a time and venue for the interview.

Thank you once again for your prompt reply to my invitation. I look forward to meeting you for the interview. If you have any questions relating to the proposed interview, please do not hesitate to contact me either by 'phone, fax. or letter.

Yours sincerely,

Appendix C

Copy of the interview schedule

The interview schedule

Q: Question
P: Probe

Pre-school

Q.1 What types of experiences in art making did you have before entering Primary School?'
P.a Art materials? Colouring books? 'Magic' painting books?

Q.2 What kind of exposure to works of art did you have before you began school?

P.b Art works in the home environment?
Art books at home?
Art gallery visits?
Museum visits?
Family or friends who were involved in some aspect of art?

Q.3 Do you recall having any notion of what art is at this early stage?

P.c Did anyone with whom you were acquainted or perhaps a particular place have a special connection to art for you?

Primary school

Q.4 In your primary school years, do you remember encountering any particular works of art which were considered to be exemplary?

P.d Were these works in the form of reproductions or were they original works?
Were there art books available for viewing?
Did you attend art exhibitions?

Q.5 Were there any learning experiences provided in the school setting given in connection with examples of artworks whether in the original form or reproductions?

P.e How were they used?

Q.6 Outside of the school context, were you shown or did you encounter any works of art?

P.f Gallery visits?
Art books?
Art in the home environment?
Relative or friend who was an artist?

Q.7 Was there any particular direction given to you by an individual in relation to experiencing works of art?

Q.8 During your primary school years, what kinds of art making experiences did you have?

P.g Which materials and techniques did you experience?
What kind of role did the teacher(s) play?
Are there any particular projects or learning experiences that you remember either from a positive or negative view point?

Secondary school years

Q.10 During your years at secondary school, what kind of involvement did you have in art making?

P.i Types of materials/ projects/ techniques/ processes experienced?
What kind of role did the teacher(s) play?

Q.11 Did you make art outside the school setting during your time at secondary school?

P.j Types of materials/ projects/ techniques/ processes experienced?
What role, if any was played by a friend/ parent/ carer?
Did you attend special workshops/ holiday camps where art experiences were provided?
Were these experiences a positive or negative influence on your development as an artist? In what way?

Q.12 Can you recall any particular influences on your art making?

P.k Art books/ reproductions?
Images from the popular culture such as comics, movies, television?

Q.13 Did you have some image in your mind of what it might be like to be an artist?

P.l What did you do to further develop/ refine this image?

Q.14 What do you recall were the major influences on the development of your personal identity as an artist?

Q.15 During your years at secondary school, what opportunities did you experience to enable you to learn to use art criticism strategies to analyse works of art?

Q.16 Were you shown works of art that were considered exemplary, or did you encounter any in the school setting?

P.m Did these encounters have any influence on your own art making?

Q.17 Did you encounter works of art outside the school setting which you considered were exemplary?

P.n In the home environment in the form of reproductions/ original works/ art books/ sources of popular culture (e.g. comics, magazines, television, record covers)
Art gallery visits?

P.n Did any of these encounters influence the imagery/ techniques/ processes used by you in your art making?

Q.18 In either the home or school setting, did you copy the work of other artists?

Why?

Q.19 Can you remember any exemplars that you consider were particularly influential on your artistic development?

Current involvement

Q.20 Since becoming involved with art as you are now, have you, at any time felt that you have consciously endeavoured to unlearn something that was taught to you:

a. in a school setting?
b. outside the school setting?

P.o In what context?

P.p Why?

Q.21 Briefly outline the kinds of involvement you have with art at this time.

Q.22 What connections are there between your current work and your childhood experiences with art?

Appendix D

Ethics form

University of Tasmania

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RESEARCH: FORMATIVE INFLUENCES ON RECOGNISED ARTISTS

AGREEMENT FOR INTERVIEWEE

I have read the information supplied about this research project and any questions I have asked have been answered to my satisfaction. I agree to participate in this investigation and understand that I may withdraw at any time without prejudice.

I agree that research data gathered for the study may be published provided that I cannot be identified as a subject. Furthermore, the taped interviews will remain strictly confidential.

Signature of subject .....

Date .....

I have explained this project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

Signature of investigator .....

Date .....

Appendix E

Sample of a transcribed interview

13/10 1993

I made mud pies before I went to school. I can remember drawing on a wall at home. We were brought up in the Dr. Spock era when you were allowed to do - we weren't told no very often. We basically wrecked our house. We moved a couple of times we made such a mess of our houses. We were allowed to do a lot of things we weren't told - I don't remember being smacked My Dad smacked me once. I can remember it hurting him more than me. We were basically encouraged to think that we could do what ever we wanted with in reason. We were always reasoned with and so I think that there was an expectation that we should be creative. Any thing was possible.

I did lots of drawings but I don't remember much about them.

Pencils and pens were used for drawing.

I remember being very pleased with the first felt tipped pens that came out - they were brought out by Disney as cartoonists pens and you had to - they were big and clunky. I think they had to be filled with colours, but they were supposed to be the sort of pens that were used by the Disney cartoonists.

I had Magic painting books.

We lived in the city in Melbourne in Malvern, it was just suburbia.

We had quite a lot of paintings and things around. I have a very strong formative memory of a painting from my great aunt's place - which I now have - a watercolour and I'm convinced it has had impact on every thing I've ever done since. I can remember when my aunt died, she was in the big, old, family house, and they'd been there a long time - she died and my father and his brothers were organising the estate and there was a debate about who would get what they got together over a whisky around the family dining table and I remember begging dad to get the paintings and prints and particularly this painting which as always been mine ever since and the interesting thing about that is I'm sure it was when I was at primary school falling in love with a water colour in a gallery in Malvern - there are a lot of Antique shops in Glennferrie Road - and there was a fabulous watercolour - I'm convinced it was by the same person - and begging Dad to invest in this painting but I can remember the impact of this painting.

It was the colour blue, the subject the sky - the fact that there's a central subject - it's a classic style divided into the Golden Mean proportions

but it flows from an area of great detail which blends of into very soft atmosphere - these were the attributes that impacted on me.

My mother had an elderly cousin who'd been a governess in India and she'd also been a Colonel in Queen Mary's army and she had a fabulous collection of things - she had an enormous marble in her hall all sorts of Empire things every where and art works and Indian relics and carvings - this sumptuous collection of treasures and this elderly very well spoken woman absolutely smothered in powder and lipstick and eye make up - she was wonderful!

Mum phoned her one April fools day and told her that the Queen and Phillip were getting a divorce and she said Oh! That dreadful Greek I knew it would never work! Mum said no that's wrong Prince Phillip is divorcing the Queen .What! He drove her to it that poor girl , that poor queen!

Mum inherited the marble but sold it and I've had a passion for marble ever since.

I have a water colour that my grand mother gave me that I remember as a child. As a very young child I copied it.
My grand mother had quite a collection of water colours.

I had much more contact with water colour than I had with any other medium.

We had a painter Norman George who was well known who lived over the road but the most impressive person in my early life was my godmother who was quite a distinguished water colourist, painting birds and flowers in the 1940's.
After years of not seeing her I've just made contact with her again and I'm getting ready to write some articles about her. She was the wife of a surgeon so she had no financial reason for painting - she just loved it and she's been working for the last 40- 50 years building up a wonderful body of work they are influenced, I now realise by Japan because of the lovely space and design and lots of white paper and she has turned out to be a kindred spirit all these years later. I remember going to her place and her working on paintings of birds using specimens from the museum and also attracting honey eaters to her window and lots of paintings of flowers like fustics and roses.

My aunt used to paint water colours and she'd done some illustrations and I was impressed by those.

I saw my godmother at work, but not the others.

I remember very early on saying that I was going to be an artist, or an architect or a draughtsman. I was going to draw! That's what I was going to do - something that involved drawing. I had no idea what it meant but always I was going to draw.

Later I had a reaction against it but I came back to it but I was always going to be an artist.

I was very impressed by my older brother's drawing ability and very - you know how children develop systems for drawing - and some where he got a system for drawing a head which has never left me and I virtually cloned his system up to primary school. I was very impressed with people like my brother drawing around me. I have a younger brother but they're the only people that I remember having an influence on my work.

Norman George was a prominent painter - well established, full time professional who lived from his work for years. I had no contact with them but George Bell was a cousin of my father's and the Bells were family members. There were all sorts of art contacts in the family that I never had any contact with.

The Carnegies had an extensive art collection and they're dads cousins but I didn't see the work.

I went to school at Grimwade house at Melbourne Grammar which was quite a long trip on the tram.

We didn't have an art room. I don't know when we did art in class. I have no memories of primary art.

The most impressive art experience from Primary school was - we had a teacher when I was in grade 4 who could really draw and on one occasion he drew a cowboy fort with Indians all around it on the black board and it was so impressive. I remember that vividly - I remember the image, I could almost re draw the fort now it made such an impression on me, but it also affected my time as a school teacher - the idea of teachers illustrating things on blackboards and actually showing people how an art work is created. The actual process and when you see the process it becomes part of you - you experience it with your eyes and you experience it with your body really and it comes into you and it comes out of you - I was very impressed by that experience. His drawings were fantastic.

There was an emphasis on music but not art.

At home we went into a period of crisis because mum drank so we were classic kids growing up in an alcoholic house hold so probably from about grade 4 on I stuffed myself with food, became extremely fat. It was a case of surviving. When I drew, it was as much to escape as anything else.

Mum when I was 14 stopped drinking It was a very formative time and we were very escapist at home I don't remember much about drawing and painting at home.

I loved comics. I collected them and I have all my original comics. I have always had a passion for them and I collected many different titles.

The Phantom was always a special one, then later on when I became a teenager some comics came out that were very well drawn at the beginning and I avidly collected them but they gave me night mares all the time so I ended up - and they got sicker and sicker - I couldn't read them, I used to collect them for the drawings but I couldn't be bothered with the stories. Mad,
Phantom, Batman - often the best drawn comic of the lot - in some ways - I did copy some of them but I don't have much memory of it .

I do remember at some stage at high school naturally doing contour drawings. I could look at something and draw it exactly. I had a phenomenal ability just to draw and that was one of the things that made me think that I was going to be an artist, but I recognise now that there is a lot of truth in the left / right hemisphere theories and I was just simply tapping in. I know that at that stage it was not any thing special to me that I could draw . It was remarkable to me that other people couldn't. It never seemed special to me. It seemed special to everyone else but when you think about it it's nothing special, it's just that others couldn't do it.

I drew guns and planes crashing and scaffolds and nooses and guillotines and lots of other things. I didn't do horrible pictures of things happening to people but weapons of destruction loomed high.

Visiting exhibitions or galleries was not on the family agenda during my years at primary school.

We were very much into making our own entertainment we were into all sorts of devilment ; we made every conceivable weapon you can think of; we invented hand grenades; built huts; made cross bows ;went to my uncle's farm a lot; we went camping.

Television made a great impact. As a very visual person, television had a big impact; I remember particularly loving the Mickey Mouse Club which is all visual and lots of cartoons. I remember the cartoon festival at the movies when we went for the afternoon to the Metro at Malvern. I loved cartoons.

Fantasia came along when I was a child. That affected me profoundly. I had nightmares about the Night on Bare Mountain all my life The mountain has stayed with me all my life. The face of the devil has stayed with me all my life. I recently sold a painting to Apple Macintosh in Melbourne for their board room and I was shocked to see a tape of Fantasia the other day and realise that what I had done to their board room is the mountain and if they ever see Fantasia they'll recognise that that's the mountain. This particular mountain shape is all through my work and I'm sure that some of them come from Fantasia. Profoundly affected my life - right from night mares to my whole view of classical music and art I'm sure.

I love drama and I ended up teaching drama at high school. I trained as an art teacher but moved into being a drama teacher one reason being that there's no medium to get in the way of the kids expressing themselves.

I have very strong memories of radio plays like Hop Harrigan and Tarzan and I have a collection of them on tapes and record.

Secondary school

When I moved to the Secondary part of Grammar from Grimwade House there was a marked change. Art was a particular area of study. There was an art room and the art room became a refuge for me. It was some where I belonged, but I didn't belong any where else in the school.

Melbourne Grammar stressed sciences, maths and sports. They seemed to be the big things. They talked about having art as a priority and they prided them selves that John Brack had the art master - he had left just before I got there and then his successor
was Ron Mellor who lectures at R.M.I.T. writes books - he was a real character and I think that it was as much that he was a real character as anything else that made that room a delight.

I realise now that it's one of the things that an art teacher can project is being a character it gets you out of all sorts of other responsibilities. His art room was definitely a refuge.

I wasn't fascinated by all the art that I saw , if I saw something that I liked, I'd absolutely fall for it and it would impact on me.

The thing that I really enjoyed was drawing. It seemed to me that I was moving into drawing - drawing was the one thing that I could do, and I could excel, so I seemed to be like the best drawer in the school, it was sort of taken for granted and so that was something that you did - it wasn't regarded as anything important.

From the age of 12 or 13, I took up Judo and got very involved in that and that was my big interest and escape from life and probably I took up Martial Arts for self defence, but it pretty soon fascinated me beyond that. I had the choice of either being a muscle head because I was into Judo or a wimp because I was into art. I was one of the two extremes and I would get into trouble for both. I can remember being hauled before the headmaster (one of the few times he ever spoke to me) and instead of going to school sports on Saturday to barrack I had gone to a Judo competition as a competitor. He basically made me feel ashamed of myself and in fact what I had done was I'd gone to do something instead of watching the school team, and as I left, I remember the next kid who was queued up I could hear as I left :Well I hope you've got something better to say than that muscle head!

Well, I was a muscle head and a wimp because I was hopeless at school sports and I hung around in the art room - I couldn't win either way so I cultivated both. I had no notion of what it would lead to and I think that the fact that I was good at drawing probably served as an escape for not being good at academia and impacted on my studies because I was going to be an artist - therefore I wouldn't need to be good at anything else and I didn't concentrate on studies at all.

I used fine line pens. In science classes, I would regularly get 10/10 for the illustration of the experiment and absolutely nothing for the experiment, so I'd usually team with somebody and do all the drawings and they'd be Gothic masterpieces and yet the write up was a catastrophe.

Any thing that involved drawing - and I'd illustrate all the margins in my books and get into trouble for that and ....

I don't remember anything about painting, we didn't have textiles there was a ceramics corner in the art room. I don't remember it as being important.

The thing that was impressive about art was the fact that the art teacher could make the artists seem like really interesting characters. He knew about who had been sleeping with who and who was what sort of eccentric and the whole thing came to life when he talked about it.

There was an emphasis on history of art through out high school but it was at matric. that I enjoyed it .

I do particularly remember the notion that artists were characters and their lives were interesting and so on. So while I was talking about becoming an artist, I had no notion as to what an artist would really be and I got quite a shock when I left and went to the gallery art school when I found out the reality of being an artist was.

I thought that it was only talent I seemed to have and the fact that I was interested in Japan and Martial Arts seemed to have absolutely no connection to any thing I might do. The other thing that was important to me was I'm sure that I was escaping from my home environment - because it was difficult at home I was a teenager and Mum had a drinking problem but at the dojo they accepted me and I was immediately treated as an adult. I had a key I was an assistant instructor and I could help with the juniors as I grew older and so on. Aikido had only just started in Australia and I was one of the two senior people - there were two of us started at the same time - it was just more and more fascinating and in the end it came together with my painting but years later. As a result , my art development is more in line with the oriental approach that you don't mature until much later so that if you look at the formative influences on my life, you'd have to look at them over 40 years.

At school, drawing was something that I enjoyed, that I could do naturally and art was something that was automatically going to come my way.

School I think gave me the false illusion that I was one of the few people that could draw therefore it was a natural.

But when I got to the art school, everybody could draw and that had a big effect on me.

At home I made a lot of art which was very separate to the school art. I was interested in drawing and I ended up years later majoring in life drawing. I was one of only two people who majored in drawing.

Drawing was my thing and I followed it right through academically, but the figure was the big subject for me and I think as an adolescent it was

sexual as much as anything else you know - voluptuous figures and all the rest of it.

I made lots and lots of drawings of naked women and being very embarrassed because my cousin or some body found one of these drawings and I was embarrassed.. One I had screwed up and thrown away and she had found it and took off and I chased her around the house trying to get the drawing from her.

At home, drawing was something that I always did.

I didn't paint at home. I was never going to be a painter. I didn't think I could paint. Now I realise that water colour is my form of painting has evolved from drawing and I can now see the connection, but they used to be two separate things in my mind.
School promoted that separateness.

At home I continued to use pencil and pen. I often did drawings in pencil and worked over them in pen. I fell in love with Norman Lindsay's work again , an adolescent fantasy and fabulous technique.

We had a family connection with Norman Lindsay in that my mother's cousin was his doctor for many years.
He had a fabulous collection of work. Norman sometimes paid his bills in paintings and gave them as Christmas gifts They had 20 or 30 Lindsay's. He was really impressive and I have a collection of books on his work. He had a sense of humour as well.

Early 20th century newspaper caricatures - I loved caricature - all people but no landscape. By the end of high school I had discovered Lautrec - he was the one who most impressed me - interestingly, years later when one of the modern masters exhibitions came to Melbourne, I went to see it to see the Lautrecs and Ingres and I was so unimpressed with the Lautrecs in reality
but I saw some Picasso paintings and they blew me to the other side of the room, I'll never forget them I'd seen Picasso in reproduction but I had never seen a Picasso and the images still vibrate in front of me , I was so impressed. They awakened me to the fact that there is a magic in art.

I copied the Lindsay drawings quite a lot. I was really self taught. I had books on How to Draw and learned a lot of things from them. All this was out of school. I used to hang around in the school library all the time because I stamped around with my head down and my shoulders up and tried to keep out of the way and had few friends who did the same thing. In the library, I would read Punch and looked at the

cartoons. I loved Punch cartoons : Thelwell and so on I loved pen and ink and the Punch style was very influential.

I made all my friends when I left school, people say that I'm gregarious and out going and wide circle of friends

At school , art was very much the soft option something the school could be proud of but it really it was the notion of a gentleman basically should go into the army or the church or a business and if you can cultivate yourself in the Renaissance sense by also painting and drawing it'll - you know - like the officers learning to paint so they could use their skills in India it was that attitude that art was apart of rounding yourself but it wasn't a serious occupation.

I never saw any of my teachers making art or demonstrating. That is what I've spent the rest of my life reacting to. I went to a really straight , traditional snobby school and rejected the system totally and I've never taught any where else but in what is loosely called progressive schools now.

My Aikido master was a strong influence on me. He was the person who taught me art but he never taught me art. There is a close connection between art and Martial art in that It has a lot to do with dance and you interrelate your mind and your body; you're moving through time and space; you have to create a harmony with the things that are around you; you have to assess situations and respond to them; you may be repeating something that has been done before, but because the situations are different and changing every time, you have to create uniquely and afresh each time. Ultimately you have to move in a way which is intuitive yet conditioned; you can't be laboured and fixed , you have to be free and floating and your self.You have to be able to know your self intimately; you have to see your activities be one where you meet your self face to face and if you can't face your self face to face - there's the problem. You have to know yourself very clearly and every time you work you meet your self very clearly. Now the other thing is that in the Orient, I believe art is taught in much the way that Martial art is taught and that is you take a master because you see some body whom you aspire to - you feel it physically, you feel it spiritually, you want to do it, you must do it, you fall in love with it, this person epitomises that and you then ask if you can be taken on as a student, you then do exactly as you are told, you repeat exactly what you are shown despite the obstacle. For years and years thinking you're only learning to clone them but in fact because you're different you can't possibly clone them and ultimately realise you've been given every thing and that you are set totally free because you've developed a new naturalness which you didn't have - the thing which started off as a

technique becomes an extension of you and you are set totally free If you look at it summed up , in the technical sense of the medium that you're working with you are taught the fundamentals of the medium from the basis up. no questions asked; do as you are told; this is what went before you; this is what you'll need approach which frees you from any need to express yourself creatively from any other obligation than simply getting on with the task and ultimately creates a new you and you realise then that everything is creative. you have to create your self a fresh every day. So that's where I learnt about art and that in turn took me to Japan, there I discovered the Japanese gardens and every thing else and the interrelationship of all the arts and that's where my life really became and so I ended up a Japanese artist and I am unquestionably a Japanese artist rather than an Australian. That was my real art training. that was the most profound influence on my activity as an artist - it was that that set me free to become an artist because prior to that I was pigeon holing art but now I feel free to be myself and I'm just an artist because I'm an artist. I'm a painter because I'm a painter.

I'm moderately impervious to what every one else is doing.

Appendix F

Sample of an interview formatted for use with NUD.IST

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*Interview with ... on 1 September, 1993

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The type of art making that I can remember most was making scrap books. It was always on a rainy day and Mum used to keep old magazines and things . We used to cut things out and make scrap books.

We used home made paste made from flour and water. I don't know what has happened to those scrap books but they were the things that I always remember making, and it was sort of made very much by choosing a picture and putting it where you wanted to on the page. Sometimes we did combination family things but quite often we just had our own page to do things with and I often think that influenced the sort os way I put things together. Layering and collage and all those sort of things. Because my parents were doing art all the time - they were both still painting at that stage - both of them. I think they considered that we couldn't make art until we could learn how to do it like them. So we weren't actually encouraged much to draw because it was always wrong by the parents.

We were somehow excluded from drawing before we went to primary school because it wasn't yet art. Later on I always found child art really interesting and I can't ever remember going through that stage. We used to draw on slates but they were erased so slates were used more at that stage thaan anything else.

We used chalks on the slates and then they were rubbed out.

They were slates with wooden edges around them.

At primary school our only kind of art work was with the pastel books. We never had paint at primary school. I still have the books and when I look at them they are so tight and formal.

My parents were interested in landscape painting. My mother was taught at art school. She was also interested in Art Deco which was the Lucien Dechaineaux influence. She was taught by him and her work was fairly loose and painterly. My father was taught by Godfrey Rivers and his work was sort of fine and meticulous but it was landscape as well. At this stage he would have when I was at primary school , he had given up painting and had taken up photography - coloured photography which - he had a lantern slide thing so that kind of meticulous detail was taken over by making coloured slides. I can't ever remember him going out and painting.

I did see my mother at work. My father's paint boxes and easels were still around but he didn't go out and do it anymore.

We lived in the country and he was a clergy man in the country and at that stage we were living at Buckland. It was during the War so there was very lottle contact with anybody else. In fact no contact with other people making art.. My father used to go to the Royal Society and as I got older, I sometimes went to meetimgs with him which was in the old museum in Hobart.

There were lectures there about all sorts of things. About science as well as the arts.

Another big influence from my father was woodwork. He always had a work shop and we were allowed to go in there but we weren't to touch anything. I can remember just standing there for hours. with my hands behind my back , watching at how he did this. Then it was very easy for me later on to make things.
cabinet maker. He made that tall boy there - it's one of the few things to have survived. He made some of the furniture in the house and was quite good at it but during the war he was mending other people's cars as well. He was into mechanics as well as woodwork. he could handle all the equipment.

It was the hands on thing that I think was a strong influence.

His paintings were around the house. there were 6 or 8 of them in the living room and in his study nobody elses paintings though. There weren't reproductions. in other people's houses there were reproductions, but in our house there were real pictures.

My mother was aware that I was interested in art. I suppose she must have been as she always had it mapped out what we were going to be besause she was a very dominant person in the family. I was going to be a kindergarten teacher because she knew you had an art training for that. and so she'd sort of mapped that out. My sister was going to be a jeweller because she liked fiddling around with little things. It is interesting that she has ended up sort of doing that in her later life.

The big thing that I see in retrospect now was that you weren't an artist until you learned how to do it properly. That attitude went right through until I was 16 and then because I was interested they

didn't really like that because I was too serious about it. It was O.K. to be a teacher and go and make art on the side but I think my father was aware of the emotional dangers - the tight rope sort of thing and my mother just thought it was terrible because they were all Bohemians. So from both sides I kind of got discouraged. They wanted to discourage me.

This was when I was leaving high school and the question of :What are you going to do?

We went to the city once a month - this was during the war - to buy food, and my father went to a clerical meeting but I can't remember going to a gallery or exhibition.

The influence was from the books. We had free access to the study, which was where all the books were. From my primary years I remember the books and the old wind up gramophone It was a Sunday thing because we weren't supposed to do anything else. I had to ask for particular books and they were taken down - a bit like the British Museum - I was given some books to look at, so that it could have been fairly early - but at least after I had learnt to read I think.

I can remember having Magic painting books - I think they may have come from grandparents.; I don't think mum and dad thought much of them.

Colouring books and coloured pencils were a slightly fringe activity but we were encouraged more to make the scrap books.
It was an impoverished house hold in terms of money.and so the scrap books was an economical activity. Colouring in books cost money.

We weren't allowed to have comics because of the aesthetic issue.
I didn't go through a stage of copying Mickey Mouse and that sort of thing which was very strong at that period.

When we went to school we used to have stalls where books were swapped and bought and we'd bring them home and they'd say no! You can't have that. There was an anti- folk tradition.

There were two art magazines at home one was The Studio and also Art in Australia I don't know how they afforded them but some of them may have been old copies and my father used to get a magazine Popular Mechanics and also an Archeology one which was called Art of the Past or something like that. He was very interested in Tutankhamen and the archeology stuff that was going on.

In primary school we had about 40 minutes a week at pastel drawing with very little direction, you know - do something.
There was no instruction at all and it was very tight.

My mother used to go to the school and help teach - she taught sewing - and sewing has always been very important to me . I remember some of my early reports said : She can't do anything else but she is a neat little sewer. I had dyslectic problems which nobody knew about then.

I wasn't much good at maths and english the sort of things you're supposed to be good at I was a neat little sewer. There was nothing

about drawing in those early reports.

We had a couple of good teachers. It was one of those one teacher schools. I think through my father's influence who kept complaining about the bad ones, they did send some good ones.
Sam somebody ... and you know he did a lot - I can remember the length of a mile because we went with a rope which was a chain long or something . The whole school walked a mile. He did those really practical things and we had nature study and we lived on a big block of bush and so we spent a lot of time building bush houses.

In the school there were reproductions - the standard two or three pictures on the wall. The later Primary years were spent at Hamilton. It was just a little bit bigger and there was probably more going on there.

My mother didn't like us being at school more than we had to be there because she thought the kids were rough and we used to walk to school and I can always remember walking miles behind, I was always interested in looking at things. Every body else was already at school. We had to leave school at the end of the day and go straight home and do the things they had for us there.

We didn't listen to the radio in these early years, because the war was on and our parets didn't want us to know about the war. So we were never allowed to look at papers. I can vaguelly remember maps and swastikas but we didn't discuss the war.

Later at Hamilton I was an Argonaut. Actually they were my first real experiences doing my own art was through the Argonauts. I used to send it to them.

I used to listen every afternoon.I'd come straight home from school and listen to that. By then I was doing my own things. I was painting. My mother was starting to teach me when I was about 11. I remember once out in the garden with her when she was showing me how to draw a tree - it was by systems - like you don't have to put all the leaves in, you put the shading on and so on. So I was beginning to be taught and I must have had paint boxes by then.

By early high school I was drawing kneeling figures in forests and I can vaguelly remember that which was a bit like the Icarus series later on. There is a bit of a link there. They were very dark and moody. I wasn't doing the sort of things I was supposed to be doing which was pretty landscapes - they were trying to teach me that - because that to them was art but I was sending these other things away to Phideas and I had a stack of blue certificates. So I was starting to get feedback as to whether they were O.K. or not.
I was getting approval from Phideas . I never showed the family much of what I was sending off. I'd put them in an envelope and pocket money was spent on stamps. This was during grades 5 and 6 I suppose.

My brother had gone off to school - he was older and not around very much. Later he became a boat builder. My elder sister had no interest in art and my twin sister - we were both interested - I don't think that Fran ever sent much off to the Argonauts, she was ... it was pretty much an isolated activity for me.

Scrap books were still being made at this late primary stage.

My mother would have wanted me to copy things - you know - that's how you do it approach.

I can remember in my early years at Hobart high school trying to draw the mountain I must have been pretty influenced by that - this is how you do the landscape thing - but it only applied to landscapes because neither of my parents were interested in drawing figures and there was the Art Nouveau design thing where you sort of filled in between the edges - and I never took off on that much either , so there was this private little world which I was involved with figures and the ego image and things like that. These were not done at school, I would have been exposed at school.

Ther secondary school for me was - well I just wanted to go at aged 12. It was leaving home - I feel that I left home at 12, which was really important to me because my secret life didn't have to be so hidden. And my sister was always a year behind me at school because it was the selective system then and she didn't pass the first time she sat so she was 2 years behind me and in a way I didn't have to play the twin role. I was playing it at home all the time but I didn't have to play it any more which was kind of nice.

My mother favoured my sister and my father kind had a sympathy both for me - I was glad to get away from that. Straight into an art class and my teacher, Eilleen Bauld knew my mother and knew that my father painted - my father had been an ex- pupil - you know, straight into the hierarchy sort of thing and art class was all I lived for in a way. I immediately found a niche that satisfied me and I was good at it and it was the only thing I had been good at becaause of the learning problem which was starting to disappear. Then when I started to learn French it was totally impossible because of the dyslexia. I still can't handle foreign languages and Maths was hopeless - but there was always art and then it became an elective and so I took it right through but I had to do cooking but sewing went with that so again it was O.K. and I didn't have to justify it at home anymore - this is what we do at school, this is new what we are taught. They still didn't approve much but they couldn't really dispute it anymore.

Art was pretty formal. There was an art history segment and there was the practical and it was guided by lesson plans but I was always pretty successful and I spent every lunch hour in the art room. I was boarding at a hostel connected to the High School.
That's where the swapping came in. Because I was at a hostel and we had to do home work any one who had to have a drawing in their social studies or science books I did their drawings and they did my maths and French. I'm sure that the teachers knew because all the books were the same because they were done by me. It gave me a lot of practice and I enjoyed doing it.

Those kind of drawings involved copying things, and for art history we had to copy images. But we learned some skills through this process.

I took biology because I was more interested in geology and biology.

but again I'm sure those choices were because you had to have drawings in the books.

I just went for the things where you had a nice book you could draw in. And geography - you know - they were all choices that I finally made had the related drawing aspect.

Matric ended up geography, biology, art and geology and I failed art! I almost credited in geography and I passed the other two but I failed art. Although I had got credits all through school years I failed Matric just because it was assessed outside. I was doing ,my emotive stuff and it wasn't the sort of stuff we were supposed to be doing. Like it wasn;t the sort of stuff we were supposed to do. and I tried again and did a supplementary in history but I still didn't pass. I never passed Matric art.

But all through the other years it was credits and credits in social studies because of the good books and failures in maths and french. I had problems with English until Bernard Mitchell took me in 3rd year - C class - and there was an immediate rapport. He took the trouble to work out what the problem was because it was obvious that I wasn't dumb but there was something , and he took the trouble to explain the structure of the language and I used to go back and do some extra work with him.

It was too late by then for me to improve my maths.

Eilleen Bauld was my teacher and we used gouache right up until matric. Once I got into oil paints my work freed up again because I was making art like it's supposed to be made. So may be that was something that went wrong at Matric level, because Quigley was teaching and she was friends with my mother and the whole link was made again. May be that was part of the problem too. Suddenly I wasn't allowed to do the more emotional things because it was real art now and no kidding around.

Remember the kneeling figure in the forest - there's a few pictures I can remember that I started to think Oh! This is sort of like writing or this isn't any different from anything else really and it's not illustration so it was sort of a realisation that it was me that wanted to do it all along and I could do it and I remember my first painting in art school - my first year after leaving high school - this little picture that has disappeared or been burnt or something That picture is the point when I said O.K. fron now on all I have to do is say what I want to say because this little picture was just absolute click! It was what I wanted to say and it was sort of an abstracty thing and it was abstract enough to be moved from all the other associations that I thought were supposed to be art and people liked it, so I got three things and Click! You know now I can go on doing this for the rest of my life.

This was just immediately after leaving high school. They didn't worry too much about not Matriculating because Eilleen Bauld had said you're not going to make a successful teacher forget about that you're not going to be able to go to art school because the only way you could go to art school was to get e scholarship in those days and you're not going to be a successful teacher because I'd had a mini break down in B class it was just teenage trauma really but every one

took it so seriously. Where as my sister, Fran
was sort of two years behind and she went through all the stages and
became a teacher.

The question was what am I going to do? I am going to find myself a
job. Partly through Marg. Luckstone but I went to the Visual aids
centre and had that job for 4 years illustrating what I had done in
the social studies books. Now it was adult stuff. I was earning a
living and I went to art school at night 5 nights a week.

I didn't have to join the teacher gang - you know it was Carrington -
Smith's gang Initially I did commercial art but after a few months I
thought this is rediculous I'm doing this at work I don't need to
learn how to do this I'll go and do the stuff I want to do . It was
good that I didn't matriculate because it set me off in a path that
was separate. I resigned that job and went to art school for one
year. I'd saved up enough money and then they said Oh! you'd make a
good teacher and I walked straight back into the high school
situation at Hobart High with no training.

I was the top student at art school so they went around and said
you'll be alright. It was a complete turn around.. I did my own
teacher training off my own bat with the university over the next 18
months..

I taught for 18 months and then went off to England.

Art hstory at high school was a lot to do with architecture and
archeology. We had to copy from some of the little black and white
photos in the text book. It was like an extension of the old books I
read as a child at home.

It wasn't any thing to do with picture making at all.

Art history was away for me to bridge the early experiences at home .
My mother praised me for my architectural drawings I did for history.
because they were nicely shaded.

It wasn't any thing to do with what was happening in art at the time.

B class and A class . I can remember Skira books when I was first at
art school in the 50's. Theey were just coming out and that was the
first time that we had colour reproductions and Carrington Smith was
teaching us history of art out of Helen Gardner with tiny black and
white photographs and there were no slides because there were no
colour books to make slides from. It was a funny kind of art
education from books because it was all black and white.

Eilleen Bauld had a bundle of reproductions that used to come out
of the Impressionist paintings but it was pretty limited and it was
Manet and Monet a sort of extension of my mothers way of painting it
was just a little bit more modern but there was nothing much about
modernism, I still laugh about it - semi - abstract!

Tasmanian semi- abstract which came from Rosamund McCulloch. What is
semi - abstract either it's abstract or it isn't?

The high school teachers often demonstrated how to use equipment and

processes before a lesson . I remember we went down to the art school with Marg Luckstone once and we saw a mural she had painted called The Apple Pickers and she showed us the sketches so there was alittle bit of a link with Marg and her art school work but we never actually saw any teachers making their own art.

Some times my father intervened. I remember making a lamp shade in a woodwork class and the shade had to be decorated and I went home to do it one weekend because I was going home quite a bit at weekends and my father totally took over and produced his transparent photographic paints and actually did a lot of it. Eileen Bauld was furious because it was totally inappropriate for what it was. He was very dominant - what could I do?

There was still that kind of family connection which was still very dominant. Yes, it's good and no , it's awful sort of attitude.

There was never any time to make art in the boarding house situation it was all so regimented, other than what was required for homework. Work at home at weekends was an extension of home work. But I suppose because I had a few encounters of this - you know you're not doing it right - in the end I never did it at home.

I did the illustrative work at home you know- the Social Studies books the rest was not shown .

In a funny sort of way, although it was a conflict, I still think that the home environment was so important because my father was a clergyman and he didn't have a job, like any other man had a job, he he decided when he went and visited people and he spent most of his time in the worshop so in a funny sort of way it was a kind of - it's was the artist's life - like there wasn't a job and yet there was a job. Later on when I decided I wanted to be an artist I just decided well that's what I am going to do you know - I'm just going to have a job that allows me to do what I really want to do and I have always sort of continued and teaching has always enabled me to do the other thing.

I made the decision when I made the first painting at art school . I was 17. yes , this is what I am going to do and all the other decisions are how am I going to do it. How am I going to get a jobthat's satisfactory enough for me to do it as much as I want to do it. It has always worked out pretty well and I get enough money to do what I want to do without compromising too much.

When I was working , I always tried to make it about 50/50.
Hence no family life and no social life.

It was the art in the family that first got me interested obviously, but it was very much the life style as well as the interests of my father in architecture and he sort of restored every rectory he went into, and I'm still wanting to restore houses. Those sort of things seem fairly minor , but in a way they are important.

I used to spend whole lunch hours in the art room beacuse we could go in any time. and do what you wanted to do.
There was always a few of us there - the keenies - and the group changed as I went from year to year, but I spent most of my time

there. Any where else I was insignificant , but in the art room I was the best. In later years I made the soft ball team at one stage, so I did do other things so I didn't exclude every thing. I wasn't allowed to do art on the actvities afternoon because I was always there any way so I was excluded. So I joined the stamp club and I just loved it because it was just like the scrap books.

I saw a big exhibition called British Painting and the Modern French one so we were taken to those while I was at high school.

We were taken down the street to the city to draw the Renaissance influence on the buildings and we used to go up on the domain drawing landscapes. But the biggest problem was that there were no reproductions..

John Haywood would have been the first influence but that was at art school. There were the big boys that every one talked about and they were John Haywood and Don Richardson. People were always talking about the ex students. Later on I taught with John Haywood in Devonport, he was making things where as the other art teachers I hadn't seen any evidence. Cecily Mc Kinley was probably the closest , but she was in drama. They were teachers which is what my parents wanted me to be It's O.K. to be a teacher but don't get into that other stuff.. Don't become a bohemian!

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